

VII EUROSOIL 2025
& X Congreso Ibérico
de la Ciencia del Suelo

SEVILLE-SPAIN 8-12 SEP

Advancing soil knowledge for a sustainable future

Book of abstracts



Advancing Soil Knowledge for a Sustainable Future

Book of Abstracts
of the Communications
presented to the
VII EUROSOIL Meeting
Seville – Spain
September 8 – 12, 2025

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Editors: José A. González Pérez & José María de la Rosa Arranz

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Editors:
José A. González Pérez and **José María de la Rosa Arranz**



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ORGANIZED BY: ECSSS European Confederation of Soil Science Societies · SPCS · SECS Sociedad Española de la Ciencia del Suelo

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PRESENTATION OF THE VII EUROSOIL CONGRESS

Dear Distinguished Colleagues and Friends of Soil Science,

It is our great pleasure to welcome you to **EUROSOIL 2025**, hosted in the historic and vibrant city of Seville. This seventh edition of the European Confederation of Soil Science Societies Congress brings together a truly global community, with well over **1,000 contributions**—oral and poster presentations—from **45 countries**.

This remarkable response reflects the growing recognition that **soil lies at the very heart of sustainable development**. Soils sustain life, regulate climate, filter water, cycle nutrients, and support biodiversity and food production. Yet, they remain among the most endangered natural resources, threatened by degradation, pollution, sealing, and unsustainable exploitation. At this critical juncture—marked by the accelerating impacts of climate change, biodiversity loss, and global food insecurity—the role of soil science has never been more essential.

EUROSOIL 2025 offers a unique platform to address these challenges through rigorous scientific exchange, policy dialogue, and interdisciplinary collaboration. The program spans a broad spectrum of themes: from soil functions and ecosystem services to digital technologies, carbon sequestration, restoration, education, and innovation. Beyond the scientific sessions, the congress also celebrates Seville's social and cultural richness, creating opportunities to interact, share experiences, and build lasting connections in a warm and inspiring atmosphere. By connecting science, society, and practice, this congress embodies the ambition to t**ranslate knowledge into action for the benefit of people and the planet.**

We are deeply grateful for the outstanding efforts of all contributors—researchers, students (our future), practitioners, and institutions—who have shaped this year's rich and diverse agenda. We also extend our heartfelt thanks to keynote speakers, session chairs, volunteers, and our partnering companies and organizations for their invaluable support and commitment to advancing soil science.

May your participation in EUROSOIL 2025 be intellectually rewarding, professionally enriching, and personally inspiring. **Together, let us reaffirm our shared commitment to protecting and understanding soils as the foundation of a resilient and just future.**

Sincerely yours,

José A. González Pérez

José M. de la Rosa Arranz

Congress Co-Chairs



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ORGANIZING COMMITTEE

To ensure the successful planning, execution, and conclusion of the event, the EUROSOIL 2025 Organizing Committee (OC) is formed by members that belong to the main groups working in Soil Sciences from Andalusia and Spain and includes members from the Spanish and Portuguese Soil Sciences Society (SECS and SPCS) and senior and young scientists from Universities and research centers with expertise in different aspects of the Soil Sciences. They assisted with various aspects of the event including planning, promoting, communicating, securing funding and sponsorships and volunteering during the congress.

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Santín, Cristina IMIB-CSIC

SCIENTIFIC COMMITEE

The Scientific Committee (SC) members were proposed by the European Soil Sciences Societies affiliated to the ECSSS and by the Organizing Committee from renowned scientists, technicians, and policy managers with a demonstrated interest in the development of Soil Sciences in a broad sense.

To cover a wide range of topics in Soil Sciences, seventeen General Topics (GT) were identified intended to encompass most areas of interest. Specific SC members handled these topics. For the final Program, when submitting an abstract, the authors were asked to rank their top two GT preferences for consideration. Following the review process by the SC, and based on the themes received, some GTs were eliminated and additional sub-topics were introduced. In addition, the opening of sub-topics was also considered upon request by members of the SC, individual participants or groups.

Chair:
José A. González Pérez IRNAS-CSIC (Spain)

Vice-Chair:
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Karczewska, Anna Wroclaw Univ. Environ. Life Sci., Poland

Kasparinskis, Raimonds Univ. of Latvia, Latvia

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Zaccone, Claudio Univ. di Verona, Italy

Zehetner, Franz BOKU Univ., Austria

Zornoza, Raul Polytechnic Univ. of Cartagena, Spain



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SEVILLA

We believe that the social aspect of our **EUROSOIL** meetings is important. This provide a pleasant and fruitful environment favoring scientific, technical relations and business opportunities.

Although it is still very early, we can advance that this will be very attractive and will bring us the opportunity to enjoy Andalusian gastronomy and traditions.

Destination with immense monumental, historic and cultural heritage. Tradition & modernity together in a millenary city.

Perfect location to host our event, with modern infrastructures and an excellent transport network.

Good weather and delicious gastronomy. With no doubt, Seville is one of the most beautiful & surprising cities in the World.

Renown groups from the university and research institutions working in varied aspects of soil sciences and now together for our **EUROSOIL**.

VENUE

FIBES Seville Congress Palace

Palacio de Exposiciones y Congresos
Av. Alcalde Luis Uruñuela, 1
41020 Sevilla

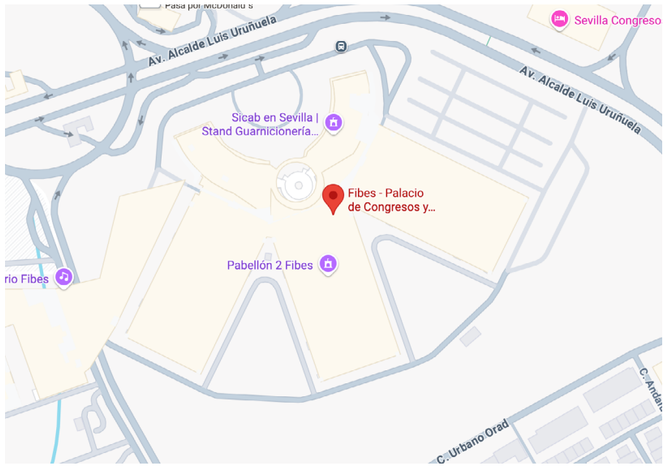


The leading space for holding major economic, cultural, social, and professional events.

Excellent conference facilities and unlimited space for exposition.

Hosting facilities close to the venue, from hostels to luxury hotels that will satisfy all participants.

Special discounts for **EUROSOIL2025**



Unbeatable facilities in a relaxed and very pleasant atmosphere.

Plenty of space is booked including:

- A plenary auditorium (>2000 pex.)
- Configurable space for parallel sessions up to 10 rooms (350-150 pex.)
- Space for Poster Exposition
- Area for Commercial Exposition, coffees and lunches
- Auxiliary space for registration, small meetings and storage

HOW TO GET THERE?

Excellent communication with the main areas of interest in the city.

SEVILLE CITY BUS (TUSSAM)

Número 27 ➡ From the city centre, From Plaza del Duque.
Número B4 ➡ (From the Nervión neighbourhood, Gran Plaza).

RENFE / Cercanías (Commuter)

Fibes is very close to a Renfe local train station, which is a quick and convenient way to get there:

Avant, **MD**, and **AVE** trains from the provinces to Sevilla-Santa Justa Station, where they connect with Cercanías (Commuter) trains.

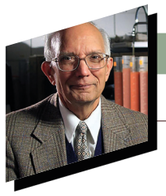
Cercanías (Commuter) **Line C4**, Palacio de Congresos Station (from Sevilla-Santa Justa Station and San Bernardo Station).

CYCLE LANE

This is one of the best and most sustainable options to get to Fibes. Seville is one of the cities with the most kilometres of cycle lanes in Europe and visitors can reach Fibes via a cycle lane. At the gates of the venue, there is also a parking facility for SEVICI, the municipal bicycle rental service.



INVITED SPEAKERS



INNAUGURAL LECTURE

(Monday, 08 September, in remote)

Dr. Rattan Lal, *Ohio State University, USA*

Soil Science and Global Issues of the 21st Century.

Distinguished Professor of Soil Science and Director of the CFAES Rattan Lal Center for Carbon Management and Sequestration (Lal Carbon Center) at The Ohio State University (OSU), Adjunct Professor of the University of Iceland and the Indian Agricultural Research Institute (IARI), India and Visiting Professor at the Pontifical Catholic University of Valparaíso (PUCV), Chile.

Dr. Lal is widely recognized globally as a pioneer in soil-centric agricultural management to improve food security globally and develop climate-resilient agriculture through soil carbon sequestration, sustainable intensification, enhancing use efficiency of agroecosystems, sustainable management of soils, and soil health.

Fellow of the American Society of Agronomy (1985), Soil Science Society of America (1986), Third World Academy of Sciences (1992), American Association for the Advancement of Sciences (1996), Soil and Water Conservation Society (1997), Indian Natl. Academy of Agricultural Sciences (1998), and Rothamsted, U.K. (2013).

Hugh Hammond Bennett Award of the SWCS (2005), Borlaug Award (2005), Liebig Award (2006), M.S. Swaminathan Award, India (2009), COMLAND Award, Germany (2009), and the Sustained Achievement Award from the Renewable Natural Resources Foundation (2017). Medal of Honor from UIMP, Santander, Spain (2018), Distinguished Service Award from the IUSS in Rio, Brazil (2018); as well as the Alumni Medallist Award (2019) and 422nd Commencement Medal (2019) from OSU, USA.

He served as President of the WASWC (1987-1990), International Soil Tillage Research Organization (1988-91), Soil Science Society of America (2005-2007), and the IUSS (2017-18), member of the Federal Advisory Committee on National Assessment of Climate Change-NCADAC (2010-2014), Senior Science Advisor to the Global Soil Forum of IASS, Germany (2010-2012), Steering Committee of the Global Soil Week, IASS, Germany (2012- 2016), Advisory Board of FACCE-JPI of the European Council (2013-2016), Advisory Committee to UNU-FLORES, Germany (2013-2019), the SPI of UNCCD, Germany (2018-2022); and the United Nations Food Systems Summit Science Committee and Action Track 3 (UNFSS) (2021).

He is Chair in Soil Science and Goodwill Ambassador for Sustainable Development Issues of the Inter-American Institute for Cooperation on Agriculture (IICA), Costa Rica (2020), member and Chair of SERDP Scientific Advisory Board of the Department of Defense (2011-2018; 2023-2025), appointed as member to the Board for International Food and Agricultural Development (BIFAD) by President Joe Biden (2022-2025).

Doctor of Science Honorary degrees from the Punjab Agricultural University, India (2001), Norwegian University of Life Sciences (2005), Alecu Russo Balti State University, Moldova (2010), Technical University of Dresden, Germany (2015), University of Lleida, Spain (2017), Gustavus Adolphus College, Minnesota (2018); Pontifical Catholic University of Valparaíso, Chile (2019); Amity University, India (2020) and IARI, India (2021).

He is ranked #1 globally and in the U.S. among Agricultural Scientists of the world by Research.com (2023, 2024), included on the list of the World's Most Influential Scientific Minds (2014-2016) and that of Highly Cited Researchers Clarivate/Thomson Reuters (2014-2023).

Professor Lal is laureate of the Gulbenkian Prize for Humanity (2024), Mahatma Ghandi Award for Environmental Protection (2022), Padma Shri Award (2021), World Food Prize (2020), Arrell Global Food Innovation Award (2020), Japan Prize (2019), U.S. Awasthi IFFCO Prize (2019), GCHERA World Agriculture Prize (2018), and Glinka World Soil Prize (2018).

Professor Lal was a lead author for the IPCC (1998-2000) and was awarded Nobel Peace Prize Certificate by the IPCC in 2007.



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OPENING CONFERENCE

(Monday, 08 September)

Dr. Panos Panagos, *EC Joint Research Centre, Ispra, Italy*

Improving Soil Health in Europe: Emerging Challenges and Opportunities for Soil Science and Policy.

Panos Panagos is a senior scientist at the Joint Research Centre of the European Commission. He has more than 23 years' experience in environmental modelling and policy developments in the European Commission.

Project leader of the EU Soil Observatory (EUSO). Panos supports a wide range of policies in the EU, including the EU Soil Strategy 2030, the proposal for a Soil Monitoring Law, the Carbon Removals Certification Framework, the Common Agricultural Policy, and the Zero Pollution Action Plan. He is also responsible for the scientific and technical support of the JRC to the HORIZON Europe Mission "A Soil Deal for Europe". He leads the innovative soil health assessments such as the ones in soil erosion, soil organic carbon, soil nutrients and diffuse pollution.

He has authored or co-authored more than 230 publications in peer-review journals and he has been awarded the Web of Science highly influential scientist award (7,000 influential researchers worldwide) for the last 6 years (2019-2024).



PLENARY CONFERENCE

(Tuesday, 09 September)

Dr. Claire Chenu, *INRAE-AgroParisTech, France*

Beneath the Surface, Beyond the Targets: Soil Carbon Science for EU Policies Development.

Research director at INRAE (French National Research Institute for Agriculture, Food and Environment) and consulting professor of soil science at AgroParisTech.

Claire Chenu has articulated the importance of soil to our planet and humanity.

She is actively involved in the science-policy-practice interface and member of the Scientific and Technical Committee of the 4 per 1000 initiative and of the ITPS. She coordinates the EU H2020 European Joint Programme SOIL: "Towards climate-smart sustainable management of agricultural soils".

Claire Chenu has provided intellectual leadership in the development of soil bio-physics as an interdisciplinary research field. Chenu's achievements help bridge the gap between soil physics and microbially controlled processes. She is internationally recognised for her great contributions to soil science in terms of understanding the biogeochemistry of soil organic matter, including the biology, effects on soil structure, modelling, and persistence in soil. She greatly contributed to our understanding of soil structure and its implications for the soil as a microbial habitat, in turn affecting major element cycles in soils.

She is a member of several committees, such as the steering committee of the Swiss National Science Foundation Research Program on soils, the scientific committee of the German Biodiversity observatories, and the scientific advisory board of the Joint Programming Initiative on Agriculture, Food Security and Climate Change. She was Vice-Chair of the "Conseil Scientifique du Patrimoine Naturel et de la Biodiversité", Ministery of Ecology (France).

In 2015, she was nominated Special Ambassador of the UN-FAO and awarded with the Philippe Duchaufour Medal in 2019 for outstanding research in the field of soil science, with special emphasis on pioneering conceptual work on the microbial-mineral interactions and organic matter dynamics in soil. In 2024 she was Doctor Universidad de Santiago de Compostela, Spain awarded her an honorary doctorate "Honoris Causa" in recognition of her methodological and conceptual contributions to the understanding of the complex interactions between living organisms and the organic and mineral components of soil.



PLENARY CONFERENCE (Tuesday, 09 September)

Dr. Laura B. Reyes Sánchez, *Univ. Nac. Autónoma de México.*

Educating for a sustainable future: environmentally livable, economically viable and humanly equitable.

Dr. Reyes Sánchez holds a PhD in Natural Sciences for Sustainable Development and is Professor of General Chemistry and Soil Science in the Department of Agricultural Engineering and Structure of Matter at FES-Cuautitlán-Universidada Autónoma de México.

She has contributed decisively to a better understanding of the soils from the American Continent. She coauthored FAO's "Soil Atlas of Latin America and the Caribbean" (2014), FAO´s Global Soil Partnership (GSP) Action and Implementation Plans of Pillar 2 (2015 and 2016), and the book "Green Chemistry Principle by Principle" (2024).

One of her priorities has been to promote the soil sciences among young children. She has authored several books and educational materials about soil sciences for kids; three children's books co-published with FAO in 2021, 2022 and 2023, ten chapters in Green Chemistry and Soil Science books. Author and co-editor of the works: "White Paper: Soil Treatment in Compulsory Secondary and Baccalaureate Education Textbooks" (2016), "Edaphological Approaches to Advancing Sustainable Development Goals: an educational perspective to build a citizen preservation culture" (2018), "Soil Sciences Education: Global Concepts and Teaching" (2020), "Sustainable soil management as a key to preserving soil biodiversity and stopping its degradation" (2022), "The IUSS Genealogy" (2024), and "Soil is a Source of Life, Water and Food" (2024).

In 2018, she became the first woman to be elected by general vote as President of the International Union of Soil Sciences (IUSS) for the period 2019-2024. She has received several prestigious awards, including the "Latin American Soil Science Award" (2014), the "Álvaro Barsellos Fagundes Medal" from the Brazilian Society of Soil Science (2018), and the Fellowship Award from the Chinese Society of Soil Science and the East and Southeast Soil Sciences Asia Federation Award (2022). She is also honored as Corresponding member of the German Soil Science Society and Honorary Member of the Soil Science Societies of Chile, Costa Rica, Guatemala, Latin-American, Poland, Spain and Ukrania.



PLENARY CONFERENCE (Wednesday, 10 September)

Dr. Peter Schad, *Technical University of Munich, Germany*

The Soils of Our Planet – A Fascinating Resource.

Peter Schad is a renowned soil scientist, Professor and Chair of Soil Science at the Technical University of Munich, Germany and since 2003, he is a guest professor at the Universidad Nacional Autónoma de México. His research interests include the soil classification, Revision of the World Reference Base for Soil Resources (WRB). From 2002 to 2010 he was the Vice-Chair and from 2010 to 2022 the Chair of the Working Group World Reference Base for Soil Resources (WRB) of the International Union of Soil Sciences (IUSS).

Peter Schad has taught soils of the world and their use, management and conservation to generations of students not only in Germany but also at universities around the world, such as Singapore, Mexico, Spain, Ecuador, and Brazil. He has developed and decisively promoted the international soil classification system World Reference Base (WRB). For this, Peter has interacted with many soil scientists at all levels and guided numerous scientific field expeditions around the globe. This have greatly contributed to the advance of general soil knowledge, its comprehensive classification and the acceptance, understanding and use of the WRB as a world soil classification system.

He has co-authored relevant reference books on soils of the world, such as the "Essentials of Soil Science" (English) and "Soils of the World" (German and English).

Awarded for 'Good University Teaching', granted by Bavarian State Minister of Science, Research and the Arts (2009) and with the IUSS Guy Smith Medal for a life-term outstanding contribution to the development of soil classification (2022).





PLENARY CONFERENCE (Wednesday, 10 September)

Dr. Heike E. Knicker, *Instituto de la Grasa (IG-CSIC), Spain*

Biochar a Magic Soil Amendment or How Does it Affect Soil Biochemistry?

Research Professor at the Instituto de la Grasa (IG-CSIC), Spain, Dr. Heike Knicker is an organic geochemist that has contributed to the Earth and soil system sciences through accurately analysing, understanding, and modelling the impact of external factors like fire on soil organic matter. Her research has made significant contributions to our understanding of the nature and stability of pyrogenic soil organic carbon and nitrogen. Additionally, she has greatly enhanced our knowledge of the formation and stabilization of soil organic matter and humic materials, as well as the stabilization and sequestration of nitrogen in soils and sediments.

She was a pioneer in the field of nuclear magnetic resonance (NMR) spectroscopy, contributing significantly to its development and applications in geochemistry and soil sciences. Notably, she recorded the first 15N NMR spectra of soil organic matter in mineral soils, sediments, and coals. Her research involved collaboration with colleagues from USA, South America, Australia, and throughout Europe. Moreover, she has contributed considerably to the formation of new research initiatives and has promoted knowledge exchange by organising meetings and encouraging participation of many research teams in joint projects.

In 2016 she was awarded with the EGU "Philippe Duchaufour" Medal for outstanding research in the field of soil organic matter, in particular on the impact of fire on humic materials, and for furthering the knowledge of the origin and properties of pyrogenic soil organic carbon and nitrogen.



CLOSING PLENARY CONFERENCE (Thursday, 11 September)

Dr. Manuel Delgado-Baquerizo, *Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Spain*

Soil Biodiversity and Ecosystem Function Under Global Change

He holds a PhD. In Sciences by the Pablo de Olavide University (UPO), Spain. Actually he leads the Biodiversity and Ecosystem Functioning Laboratory (BioFunLab) at Instituto de Recursos Naturales y Agrobiología (IRNAS-CSIC), Spain, and the BioFun R&D Unit of the UPO-CSIC, Spain. He is also an honorary researcher at UPO, an honorary researcher at Western Sydney University, Australia (WSU) and a Visiting Scholar at Colorado State University, USA.

His research focuses on providing innovative knowledge about the soil biome - the set of ecosystems characteristic of an area - in a context of global change. To do so, it uses a multidisciplinary approach that encompasses the study of environmental microbiomes, soil biodiversity, ecosystem functioning, global change and historical legacies in natural, agricultural and urban ecosystems on a global scale.

He is listed as Highly Cited Researcher Clarivate/Thomson Reuters (2021-). He holds the UPO Extraordinary Doctorate Award (2013), the "Andaluces del Futuro" Award (2018) and the "Real Maestranza de Caballería de Sevilla" Research Award (2021), the "Cadena SER Losada Villasante" Award (2023) for his work "Soil, a fundamental non-renewable resource for humans" and the "VIII Banco Sabadell Foundation Award" for Science and Engineering (2024) for its "scientific contributions and innovative knowledge of the soil biome in general and of farmland in particular to promote sustainable agriculture."

In 2020 Dr Delgado Baquerizo was honored with the National Research Award for young researchers "Ángeles Alvariño" in the area of sciences and technologies of the natural resources, for his studies of the soil biome as a key element for health and, ultimately, for life, in a scenario of global change. This is the most important recognition in Spain in the field of scientific research. The award highlights the science that is done in our country thanks to the work of researchers with exceptional careers, who dedicate their lives to generating knowledge and transferring it into applications for society.



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EUROSOIL 2025 GENERAL TOPICS

GT01. Soil Genesis, Evolution and Classification

This GT encompasses communications dealing with understanding the processes that lead to the formation of a soil, change over time, and how they are categorized and classified based on their physical, chemical, and biological properties. This topic is crucial for managing soil resources effectively in agriculture, environmental protection and general understanding ecosystem dynamics.

Sub-session GT01.1. ***Soil Genesis, Properties, and Classification Challenges***

Sub-session GT01.2. ***Soils in Time from the Past to the Future I and II***

Conveners: **F. Scarciglia & F. Kurbanova**

Soil development is driven by soil-forming factors (functional-factorial model) and their transformations over time, initially shaped by climatic shifts and, in the Anthropocene, increasingly influenced by human activities. Understanding contemporary soils and soil cover requires exploring their history — the legacy of past environmental conditions and soil-forming processes. This session will explore how past soils have shaped the current state of soil systems and the soil mantle, as well as how insights from both past and present soils can help predict future developments to face major challenges posed by climate changes and human impacts.

We expect contributions on evolutionary pathways in soils, including buried and exposed paleosols and protosoils, paleo-features in polygenetic contemporary surface soils, and soil-sedimentary systems such as loess, alluvial, colluvial, tephra, and various anthropogenic and anthropogenically transformed sequences, particularly in archaeological deposits. Investigations devoted to the classification of the listed soils are welcome. Research utilizing mono- and multiproxy soil and soil-sedimentary archives at different spatio-temporal scales, applying both traditional and novel approaches, methods, and techniques.

Sub-session GT01.3. ***Advances in Soil Mapping***

Conveners: **S. Guerreiro & A. Vacca**

Addressing global issues such as climate change, land degradation, water and food security, biodiversity loss, carbon sequestration, and human health depends on access to comprehensive and reliable soil information systems. Soil maps play a fundamental role in these systems, supporting sustainable land management and natural resource conservation by enabling the implementation of site-specific practices. To fulfil this objective, soil maps must provide accurate, updated, and harmonised information.

Given the current constraints on available resources and time for conducting soil surveys, leveraging legacy soil data and digital technologies has become essential for advancing soil mapping. The development of new software, advances in computational power, emergence of artificial intelligence, and enhanced predictive modelling techniques have significantly improved mapping accuracy and impact, offering new insights on soil genesis, evolution and classification. In recent years, numerous national and international initiatives have emerged to create, update, and harmonise soil maps, enhancing their applicability for scientific research, policy development, and land resources management.

This session includes contributions on modern methodologies and strategies aimed at improving soil mapping, with a particular focus on integrating legacy soil data, applying advanced digital technologies and harmonizing maps at multiple scales. Discussions will explore innovative approaches that enhance the accuracy, interpretability, and practical usability of soil maps.

GT02. Soil Physical Chemistry

This GT concerns the relationships between physical and chemical phenomena in soils, aiming at predicting the pathways of chemical processes over time as well as the final results under various conditions, beginning with a knowledge of structure and properties of the molecules involved in the reactions. This involves the study of soil texture and structure, thermodynamics, electrochemistry, photochemistry, and kinetics of chemical soil processes as well as the investigation of soil solutions, surface phenomena, and acid-base and reduction-oxidation equilibria.

Sub-session GT02.1. ***Soil Structure and Physical Modelling***

Sub-session GT02.2. ***Biogeochemical Cycles and Soil Contaminants***

GT03. Soil Biogeochemistry & Global Change

This is a GT of actual main interest since soils are now recognized as paramount for the regulation of the C biogeochemical cycle and global change mitigation. The studies on soil biogeochemistry are vital for predicting and managing the impacts of global climate change and to develop strategies to mitigate greenhouse gas emissions, enhance carbon sequestration, and ensure sustainable ecosystem services. This knowledge is essential for informing policies and practices that address the challenges of climate change and to promote environmental sustainability.

Sub-session GT03.1. ***Changing Environment and Land-Use***

Sub-session GT03.2. ***Generic***

Sub-session GT03.3. ***Soil greenhouse gas fluxes in agricultural and forest systems: measurements, synthesis and modelling***

Conveners: **J. Álvaro-Fuentes & R. Zornoza**

Soils are emitters of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Management practices impact soil carbon and nitrogen cycles which, in turn, influence the production and emission of greenhouse gases (GHG) from the soil surface into the atmosphere. In this context, it is essential to search and identify mitigation strategies that may help to meet the commitments outlined in various national and international regulations (e.g. the European Climate Law). Over the past few decades, various methodologies have been developed to measure gas fluxes from soils, encompassing both field and laboratory techniques which allow for precise estimations of gas emission rates under different soil, climate and management conditions. Furthermore, the data collected have helped to calibrate and validate simulation models for predicting soil gas fluxes under different land uses and regions around the world.

The main objective of this session is to present studies related to soil greenhouse gas production and emissions in agricultural, grassland and/or forest systems. We welcome contributions on management impacts, mesocosm, field or landscape-scale experiments, meta-analyses and data reviews, methods approaches and/or modelling studies.

Sub-session GT03.4. ***Optimizing roots for sustainable crop production in Europe, lessons learnt from EJP Soil and other soil root studies.***

Conveners: **J. Mayer, I. Bertrand & R. Hood-Nowotny**

To mitigate climate change, carbon sequestration and the implementation of negative emission technologies are essential. Sequestering carbon in soils through increased belowground sequestration, specifically by enhancing root carbon inputs from cropping systems, could significantly contribute to protect and increase SOC stocks, in line with the 4 per mil initiative.

A promising yet often overlooked practice involves increasing and deepening root production and rhizodeposition of both main and cover crops in extensive and intensive cropping systems. The main practices to do so are for instance the selection of plant genotypes, plant mixtures with complementarity of root system depth, mixture of perennial and annual plants in agroforestry systems etc.

This session invites contributions on topics such as measuring root traits, root biomass, root stoichiometry, root architecture, isotope labeling, and rhizodeposition to better understand soil functions. These topics should be considered alongside environmental factors like soil type, strength, and fertility to predict the impact of root systems on soil organic carbon (SOC) stocks. The impetus for this session is that within the EJP-SOIL MIXROOT-C and MaxRoot-C projects, we developed and assessed methods to estimate root carbon inputs of staple and novel crops in cropland, grassland, and agroforestry systems across Europe. We are keen to expand this network and welcome contributions from ongoing projects that may be of interest to the root community, as well as presentations of initial data or approaches from those working on modeling.

Our goal is to advance current knowledge and evaluate the potential impact of promising carbon sequestering management interventions, such as land use, targeted breeding, and soil management. These practices aim for widespread adoption of more sustainable carbon sequestering and soil restorative methods in diverse agricultural production systems.



GT04. Soil Biology & Microbiology

This GT deals with studies about the organisms that thrive in the soil (micro, meso, macro), their identification, diversity, structure, and function. Detailed insights into the complex soil biological communities and their functions using novel Next-Generation Sequencing (NGS) tools are welcome. This is a fundamental GT for a better understanding of soil functioning and its interactions with other components of the environment. It provides a scientific basis for developing sustainable practices that promote soil health, agricultural productivity, and environmental quality, all essential for addressing the global challenges of food security and climate change.

Sub-session GT04.1. ***Effects of Land Management on Soil Biota I, II & III***

Sub-session GT04.2. ***Dynamics and drivers***

Sub-session GT04.3. ***Generic***

Sub-session GT04.4. ***Session 4.3. Biodiversity Assessment and Monitoring***

GT05. Soil Hydrology & Erosion

This GT focuses on the study of how water infiltrates, is stored, and moves through the soil profile. It also examines how various factors, such as deforestation, inappropriate agricultural practices, and climate change, impact soil hydrological conditions and lead to soil erosion. These processes are interconnected and have far-reaching economic and environmental consequences. Proper management of these factors is crucial for soil conservation, efficient water resource management, reducing droughts and floods risks, enhancing agricultural productivity, and maintaining ecosystem health and environmental sustainability.

Sub-session GT05.1. ***Generic***

GT06. Soil Productive Sectors: Economy and Sustainability

Soil is a critical natural resource that supports agriculture, forestry, and other land-based industries, but is also foundational in building infrastructure. This GT aims to explore the link between soil management and economic activities, emphasizing sustainable practices that balance productivity and ecosystem preservation, enhancing the quality of activities and products derived from the soil and ensuring that soil continues to support global ecosystems and human well-being.

Session in Posters only

GT07. Soil Amendments & Fertilizers

Soil amendments and fertilizers are vital for modern agriculture, balancing productivity, economic growth, and environmental sustainability. They address soil nutrient deficiencies, optimize pH, and improve structure, enabling sustainable farming. Economically, they boost productivity, reduce costs, and support rural economies. Environmentally, help to mitigate soil degradation, reduce land expansion, and minimize deforestation. Innovations like biochar and precision nutrient management further enhance sustainability by improving water retention, reducing emissions, and promoting soil health. This GT focuses on such materials, which benefit the circular economy and pave the way for a sustainable future.

Sub-session GT07.1. ***Circular economy approaches for sustainable crop fertilization & soil health I, II & III***

Conveners: **A. Delgado & A. Laudicina**

Nutrients are critical resources for agriculture and, therefore, for ensuring global food security. Nitrogen and phosphorus are non-renewable resources that are inefficiently used on a societal scale. Nitrogen fertilizers production dependent on enormous energy consumption, while that of phosphorus fertilizers rely on mine resources concentrated in a few countries. This explains the upward trend in prices and makes the fertilizer market very sensitive to geopolitical issues, which can seriously affect food systems around the world.

Ensuring food security with more sustainable agricultural systems therefore requires innovative approaches that integrate circular economy principles into crop fertilization while contributing to soil functioning and the resilience of agricultural production to climate change. This should rely on valorizing nutrient rich streams from different stages of the food chain and from wastewater, transforming them into alternative fertilizers, the so-called bio-based fertilizers (BBF), and amendments. Treatments can involve physical, chemical, and/or biological treatments, between them composting and vermicomposting.

Biobased-fertilizers will minimize the use of non-renewable and strategic resources in agriculture, ensuring food security, and can actively contribute to improving soil health ensuring the essential ecosystem services it provides, not only primary productivity but also others such as climate change mitigation.

Sub-session GT07.2. ***Mineral Fertilization I & II***

Sub-session GT07.3. ***Chars as Soil Amendments and Impact on the Soil-Plant-Microorganism System***

Conveners: **F. J. Moreno-Racero & H. Knicker**

The term “biomass” encompasses the biodegradable components of products, leftovers, and residual materials of biological origin derived from agriculture, forestry, and related sectors, including fisheries, aquaculture, as well as the biodegradable fractions of industrial and municipal waste. Focusing on valorization and within the framework of a circular economy, converting biomass residues into high-value-added products offers significant environmental and socioeconomic benefits, making it a topic of substantial scientific interest.

Thermochemical conversion methods, such as hydrothermal carbonization and pyrolysis, provide promising avenues for utilizing waste biomass to produce valuable products. These processes convert biomass into hydrochars and pyrochars—carbon-rich solid products—that can be used as soil amendments to improve or restore soil functions and fertility. Additionally, they exhibit the potential to increase microbial abundance, activity, and quality, as well as enhance crop production. However, the production, physical and chemical characterization of these carbons, along with their potential impact on the soil-plant-microorganism system, require further exploration by the scientific community.

Sub-session GT07.4. ***Generic***

Sub-session GT07.5. ***Bioestimulants***

Sub-session GT07.6. ***Biopolymers***

GT08. Soil-Plant-Water Interactions

This GT is pivotal for enhancing for enhancing water use efficiency in arid and semi-arid areas, where climate change and resource limitations increasingly threaten sustainable agriculture. By analyzing the processes of water retention, root absorption, and plant reactions to drought, this science offers customized solutions—like precision irrigation, drought-resistant crops, and soil amendments—that boost productivity while minimizing water waste. For instance, research on biochar or microbial-assisted water retention highlights how soil health influences hydrological resilience directly. In regions facing water stress such as the Mediterranean, Sahel, or Central Asia, these advancements are not merely theoretical: they foster food security, economic stability, and mitigate conflicts arising from scarce resources. Ultimately, optimizing these interactions serves as a lifeline for dryland farming communities and is essential for global climate adaptation initiatives.

Sub-session GT08.1. ***Generic***

Sub-session GT08.2. ***Generic***

Sub-session GT08.3. ***Generic***

Sub-session GT08.4. ***Linking vegetation indices and soil properties: Advances in measurement, monitoring, and modeling***

Conveners: **A. Horel & Z. Bakacsi**

Measuring, monitoring, and modeling soil and plant properties is essential for understanding ecosystem health and optimizing agricultural productivity. Land management under changing environmental conditions, especially the changing climate, needs additional attention. Since systematic measurements of soil properties can be labor-intensive and expensive, new methods are being continuously sought to shorten the required time and effort, thereby reducing the associated costs. Hence, advances in recent technologies and methods such as remote sensing, machine learning, and mathematical modeling are improving our ability to predict soil and plant dynamics at multiple scales. This Sub-section aims to gather presentations where our understanding of the soil and plant interaction is enhanced by new methods, technology, or reevaluating collected data.



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QGT09. Soil Health

This GT deals with factors and circumstances that affect the ability of the soil to sustain productivity, diversity, and the environmental services. Healthy soils are essential for a long-term productive and sustainable agriculture, economic stability, environmental preservation and to ensure an ecological balance. Soil directly influences crop productivity, nutrient cycling, and ecosystem resilience. Assessing soil health through indicators like organic matter, microbial activity, and nutrient availability enables farmers to optimize management practices, enhance yields, reduce input costs and strengthen rural livelihoods. Environmentally, maintaining soil health mitigates erosion, improves water retention, and sequesters carbon, contributing to climate change mitigation. Healthy soils also support biodiversity and reduce the environmental footprint of farming.

Sub-session GT09.1. Conceptual Frameworks & Assessment I & II

Sub-session GT09.2. ***Carbon and Nutrient Cycling***

Sub-session GT09.3. ***Management and Climate Strategies I and II***

Sub-session GT09.4. ***Monitoring Networks and Data Platforms***

Sub-session GT09.5. ***Physical Structure and Hydrology***

Sub-session GT09.6. ***Biological and Biodiversity Indicators***

Sub-session GT09.7. ***Generic***

GT10. Soil Carbon Dynamics and Stabilization

This GT address pressing global challenges such as climate change mitigation, sustainable agriculture, and ecosystem resilience. Soils store more carbon than the atmosphere and vegetation combined, being a buffer against rising CO_2 levels. Here we intend to improve our understanding on the mechanisms of C sequestration, the role of microbial and plant interactions, and the impact of land management practices on long-term C storage. By unravelling these processes, we can develop strategies to enhance C retention, improve agricultural productivity, and restore degraded lands—ultimately supporting climate-smart policies and achieving global sustainability goals like the 4 per 1000 Initiative. This knowledge will imrove food security, biodiversity conservation, and a stable climate for future generations.

Sub-session GT10.1. ***Enhancing Soil C through Sustainable Management for Climate Mitigation I & II.***

Conveners: **J. Aguilera Huertas, B. Lozano García & M. González Rosado**

Soils are one of the main terrestrial reservoirs of carbon and constitute a fundamental non-renewable natural resource, supporting both food production and ecosystem balance. Today, the fact that they can act as net carbon sinks makes it necessary to strengthen their capacity to store carbon in the form of stable reserves as a key strategy for moving towards climate neutrality. Moreover, the accumulation, stability and circulation of carbon in soils play an essential role in the productivity and resilience of soil systems. It is therefore essential to conserve and even increase these carbon stocks in order to ensure long-term sustainable agriculture. It should be noted that nearly 50% of soils in Europe are used for agricultural purposes.

In the current context, characterized by an increase in the frequency and intensity of extreme weather events, soils face increased exposure to processes such as erosion and leaching, which compromises their health and functionality. Therefore, it is essential to apply sustainable agricultural practices that not only contribute to mitigate climate change, but also maintain soil fertility over time. Efficient soil management is key to preserve its good condition, as it directly affects the organic matter content (SOM) and the capacity to store and stabilize organic carbon (SOC).

In this sense, the objective of this session is to analyze different ways to increase soil carbon stocks in order to improve the productivity of agricultural systems, counteract the negative effects of environmental changes and advance in climate neutrality commitments. The aim is to broaden knowledge on how different soil management strategies influence soil physical, chemical and biological properties, based on evidence from experimental and field studies.

Sub-session GT10.2. ***Land Uses for Carbon Enhancement***

Sub-session GT10.3. ***Carbon Characterization at the Pedon to Micro Scale, and Linking to the Landscape Scale I & II***

Sub-session GT10.4. ***Management Practices and Soil Health***

Sub-session GT10.5. ***Effects of Soil C Content in Soil Health***

Sub-session GT10.6. ***Amended Soils***

Sub-session GT10.7. ***Forest Soils***

GT11. Soil Degradation, Desertification, Contamination - Conservation, Mitigation, Remediation

This GT tackles critical threats to global ecosystems, food security, and human well-being. As expanding land use, climate change, and pollution accelerate soil decline, research on conservation, mitigation, and remediation becomes essential to sustain fertile lands, protect biodiversity, and safeguard water resources. Studies in this field drive innovative solutions—from regenerative agriculture and phytoremediation to policy frameworks—ensuring resilient soils for future generations. Addressing these challenges is not just an environmental imperative but a socioeconomic necessity, as healthy soils underpin climate stability, livelihoods, and sustainable development worldwide.

Sub-session GT11.1. ***Generic***

Sub-session GT11.2. ***Emerging Pollutants and Microplastics I & II***

Sub-session GT11.3. ***Digital Tools and Monitoring***

Sub-session GT11.4. ***Amendments and Soil Remediation***

Conveners: **A. Karczewska & S. Norra**

This session brings together research and practice addressing the twin challenges of soil degradation and contamination. It covers a wide range of threats—from erosion, loss of organic matter, and biodiversity decline to industrial pollution and emerging contaminants such as PFAS and pharmaceuticals. Presentations will explore assessment methods, environmental risks, and innovative remediation strategies, including both technical and nature-based approaches. The session aims to foster interdisciplinary dialogue and promote sustainable solutions for restoring soil health and functionality across diverse landscapes.

Sub-session GT11.5. ***Amendments and Soil Remediation***

Sub-session GT11.6. ***Soil Degradation in Mining and Industrial Areas: Assessment, Remediation, and Prevention Strategies***

Conveners: **A. Molinero García, A. Gómez-Arias & R. Millán Becerro**

This session explores the challenges of soil affected by mining and industrial activities, with a focus on contamination assessment, remediation methods, and prevention strategies for sustainable environmental management. Activities such as mining, metal processing, refining, fertilizer production, and other industrial operations usually generate large amounts of solid wastes and effluents that can contribute significantly to soil pollution, leading to the accumulation of heavy metals, sulfates, phosphates, fluorides, nitrates, hydrocarbons, and persistent organic pollutants, among other hazardous substances. These contaminants alter soil components and their physicochemical properties, causing changes in their chemical composition, reduced fertility, and altered microbial communities, among other effects. They also pose severe environmental and human health risks. A comprehensive understanding of soil contamination through advanced characterization techniques—such as chemical and mineralogical analysis, geostatistical and geochemical modelling, and microbial biodiversity assessment—is essential for developing effective remediation strategies. Contributions on analytical methods, soil amendments, remediation strategies, and policy frameworks for pollution prevention are welcome.

This session will bring together experts in soil science, environmental science, geology, microbiology, chemistry, and engineering to discuss innovative approaches for soil remediation, risk mitigation, and sustainable land management. The platform aims to foster collaboration and knowledge exchange to advance solutions for preserving and restoring soil health in mining and industrial regions worldwide.

GT 12. Soil Natural Hazards: Fires, Floodings, Landslides

These factors pose actual significant threats to ecosystems, infrastructure, and human safety, making their study critically important. Research in this field will help us understand the triggers and impacts of these events, such as how wildfires degrade soils and its stability, how extreme flooding accelerates erosion, or how landslides disrupt landscapes and communities. By analyzing these processes, we may improve will improve the development of predictive models, early warning systems, and mitigation strategies to reduce risks. Additionally, this knowledge informs policymakers and urban planners in creating resilient land-use practices, safeguarding agriculture, and protecting vulnerable populations. Ultimately, advancing research on soil-related hazards is essential for sustainable development, disaster preparedness, and climate change adaptation.

Sub-session GT12.1. ***Generic***



GT13. Land Fragmentation, Urban and Anthropogenic Soils

This GT deals with critical aspects of study that are causing profound impacts on ecosystems, food security, and sustainable development. Research on land fragmentation reveals its role in reducing agricultural productivity, disrupting biodiversity, and complicating land management, particularly in rapidly urbanizing regions. Meanwhile, studies on urban and anthropogenic soils—shaped by human activities like construction, pollution, and waste disposal—highlight their altered chemical, physical, and biological properties, which influence urban resilience, C storage, and contaminant mitigation. Understanding these dynamics is essential for crafting policies that balance urban growth with environmental preservation, ensuring soil availability for future generations. By addressing these challenges, scientists and policymakers can promote smarter land-use planning, novel strategies to restore degraded soils, and mitigate climate change effects.

Sub-session GT13.1. ***Generic***

GT14. Soil Data Acquisition, Curation, Sharing & Modelling

This GT is at the backbone of contemporary soil science, facilitating informed choices for sustainable land management. Accurate data collection utilizing advanced sensing technologies allows for precise evaluations of soil health, while organized curation guarantees long-term usability and trustworthiness. Open data sharing encourages worldwide collaboration, dismantling barriers between researchers, policymakers, and farmers. Lastly, predictive modelling converts raw data into practical insights—such as forecasting erosion risks and refining carbon sequestration techniques. Collectively, these interrelated processes empower science and society to address urgent issues, including food security, climate change mitigation, and biodiversity preservation, rendering them essential tools for protecting our planet's crucial soil resources.

Sub-session GT14.1. ***Integrating Ground Observations and Satellites for Carbon Sensing of Soil and Vegetation I (Remote Sensing)***

Conveners: **E. Vaudour, J. Wetterlind, Y. Fouad, M.J. Marques & N. Baghdadi**

Remote and proximal data are more and more incorporated into digital soil mapping approaches and mechanistic models. Little consideration is given to the uncertainty and the accuracy of the measurements and the various disturbing factors, such as soil moisture, for the modelling of soil C, C fluxes and C-stocking practices. This session is dedicated to these issues as well as the gaps that may be found when relating in situ observations to satellites, referring to spatial design, field conditions, soil types, pedoclimatic regions, levels of atmospheric correction, spectral indices, spatial, spectral and temporal resolution, and agricultural practices. This session is welcoming contributions dealing with remote sensing of soil C, soil moisture, C fluxes and related agricultural practices, soil, vegetation and gas spectroscopy, optical, hyperspectral, thermal and radar satellite time series, proximal sensing approaches, and the coupling with process-based models.

Sub-session GT14.2. ***Integrating Ground Observations and Satellites for Carbon Sensing of Soil and Vegetation II (Proximal Sensing)***

Conveners: **E. Vaudour, J. Wetterlind, Y. Fouad, M.J. Marques & N. Baghdadi**

Remote and proximal data are more and more incorporated into digital soil mapping approaches and mechanistic models. Little consideration is given to the uncertainty and the accuracy of the measurements and the various disturbing factors, such as soil moisture, for the modelling of soil C, C fluxes and C-stocking practices. This session is dedicated to these issues as well as the gaps that may be found when relating in situ observations to satellites, referring to spatial design, field conditions, soil types, pedoclimatic regions, levels of atmospheric correction, spectral indices, spatial, spectral and temporal resolution, and agricultural practices. This session is welcoming contributions dealing with remote sensing of soil C, soil moisture, C fluxes and related agricultural practices, soil, vegetation and gas spectroscopy, optical, hyperspectral, thermal and radar satellite time series, proximal sensing approaches, and the coupling with process-based models.

Sub-session GT14.3. ***Linking Process Modelling and Digital Soil Mapping***

Sub-session GT14.4. ***Data Platforms and Digital Soil Mapping for Soil Monitoring***

GT16. Soil Literacy, Education & Art

Soil is a foundation of life, yet its importance is often overlooked. This session explores how soil literacy, education, and art can bridge the gap between science and society, fostering cultural and emotional connections to the ground beneath our feet. Achieving global goals—such as 75% healthy soils by 2030—requires more than technical solutions; it demands a shift in how we value soil. Building soil literacy empowers farmers, informs policymakers, and engages the public in soil's role in climate resilience, food security, and ecosystem health. Education builds knowledge, while art sparks curiosity and makes soil science accessible across cultures. Through initiatives from schools to citizen science, visual arts, and storytelling, we aim to inspire care and responsibility for soils for present and future generations.

Sub-session GT16.1. ***Generic***

GT17. Soils at the Crossroads: Society, Policies, and Participatory Science

Soils are central to tackling global challenges such as climate change, food security, biodiversity loss, and land degradation. This session explores how soil science connects with societal needs, policy frameworks, and participatory approaches to decision-making. Global initiatives—including the UN SDGs, the EU Mission "A Soil Deal for Europe", and the EU Soil Observatory—set ambitious targets like 75% healthy soils by 2030, highlighting the need for integrated, measurable solutions. Achieving these goals requires soil literacy and education to empower farmers, inform policymakers, and engage the public in soil's role in climate resilience and food systems. Contributions will showcase co-creation of knowledge, inclusive governance, and participatory science—placing soils firmly at the crossroads of science, society, and policy.

Sub-session GT17.1. ***Generic***

Sub-session GT17.2. ***Digital Soil Mapping and Innovative Soil Monitoring Systems in the EU***

Conveners: **C. Schillaci, A. Jones & P. Panagos**

The knowledge of the soil surveyor in the digital era has changed; thanks to the increased computational capacity of geographic information systems, legacy soil data are now seen as a treasure. The acquisition and interpretation of the soil properties and their changes over time could steer our understanding of earth processes and positively affect how we manage soil resources. Operational use of the DSM for precision farming is one of the main essential activities in today's agriculture. This can benefit from many technological advances, such as remote sensing, digital dashboards, the web application of soil modelling and mapping and cloud computing. As highlighted in the new European Soil Strategy, to tackle climate change and environmental challenges, spatial soil information and updated soil maps are strongly needed. It also applies for tracking progress toward the SDGs, providing the broader soil user community with the soil knowledge and data flows required to safeguard soils.

This Session is welcoming contributions dealing with digital soil mapping, innovative soil monitoring and data management, legacy data digitalization from soil maps, the extraction of spatial knowledge from soil survey data and remote sensing.

SPECIAL EVENTS WITHIN EUROSOIL 2025

5th EUSO Stakeholders Forum

Tuesday 9th — Organized by **The EU Soil Observatory. JRC, Ispra Italy**

The EU Soil Observatory (EUSO) aims to be the principal provider of reference data and knowledge at EU-level for all matters relating to soil. Every day they organize The EUSO Stakeholders Forum, an open and inclusive platform bringing together soil scientists, policy makers, regional and national representatives, land managers and interested citizens. It also aims to support citizen engagement and the drive towards a societal change in the perception of soils.

The 5th EUSO Stakeholders Forum 2025 takes place in two parts; the first part took part online on the 12th June 2025 and the second part, this one, was held in-person during the EUROSOIL2025.

Status of Soils Worldwide: State of the Art and Future Prospects

Wednesday 10th 9:45-11:00 Organized by **FAO-GSP**

Soils are essential to life on Earth. It is a key provider of ecosystem services, such as regulating climate change and water flows, providing clean water, food, feed, and fuel, supporting human infrastructure, and buffering and filtering contaminants. Their protection and sustainable management is of the utmost importance to ensure the future of agrifood systems and sustainable development. Yet, soils are under growing pressure due to unsustainable agricultural practices, urban expansion, land use change and conflicts which effects are exacerbated by climate change.

The aim of this event was to examine the status, knowledge gaps and future prospects on the state of soils and how better knowledge can guide global policies to ensure healthy and productive soils for all.

From Zero to Hero: Practical Insights into Living Labs and Lighthouses for Soil Management

Thursday 11th 10:15-12:45 Organized by **EvenorTech**

This event aims to provide a comprehensive and practice-oriented exploration of the role of Living Labs and Lighthouses in advancing sustainable soil management across Europe. Through a combination of conceptual presentations, real-world case studies, and interactive discussions, participants will gain valuable insights into the mechanisms, challenges, and opportunities associated with these collaborative innovation platforms.

The convenes leading experts, project coordinators, and stakeholders engaged in soil health initiatives, offering a unique opportunity to exchange knowledge, foster partnerships, and contribute to the development of resilient and productive soil systems. We invite all attendees to actively participate in the dialogue and to consider joining the emerging Community of Practice dedicated to soil sustainability.

Let's move from theory to action—from zero to hero—in building resilient, productive, and sustainable soils for generations to come.

EUROSOIL 2025 WORKSHOPS

WORKSHOP 1

Organized by **The Soil Health Institute**

Presenting "Slakes", a free smartphone app to measure aggregate stability.

Monday 8th 18:00-19:00 (ITALICA Auditorium)

Elizabeth Rieke. *The Soil Health Institute, Program Director, Measurement Standardization Lead and Soil Microbiome Scientist. Nevada, IA, USA*

Aggregate stability is a commonly used indicator of soil health because improvements in aggregate stability are related to reduced erodibility and improved soil–water dynamics. The app calculates an aggregate stability index based on changes in aggregate surface area before and after being submerged in water for 10 minutes. While the mechanism differs from traditional aggregate stability methodologies, results from the North American Project to Evaluate Soil Health Measurements indicated the Slakes method was just as sensitive to detecting changes in agricultural management practices (e.g. reduced tillage, cover cropping, residue retention). Use of the app only requires a smartphone, three air-dried soil aggregates, two clear plastic dishes, tap water, and a smartphone mount. The app is currently available for free download in the Google Play and Apple app stores.



WORKSHOP 2

Organized by **The British Society of Soil Science (BSSS).**

Missions to protect soil

Monday 8th 18:00-19:00 (BAHIA Hall)

Paul Hallett, *University of Aberdeen & BSSS President*

Andrew A. Morris, *BSSS Executive Director*

Protecting soil has been a central theme of many new funding initiatives across European nations and from EU Horizon2020, and a new Soil Health Charter to be launched by the British Society of Soil Science. This session will provide an overview of these diverse programs, hearing from both well-established projects and those that are about to kick-off. After brief overviews from each project, a panel session featuring the speakers will discuss their team's research and its potential impact in protecting soils. Topics will include cutting-edge technologies to monitor, measure, model and map soils, soils as part of the broader landscape and the interaction with people, emerging challenges such as new pollutants, and the role of soils in biodiversity, climate change and ecosystem services like pollinators.

The session was followed by a short networking event to allow people across different EU projects to interact.

WORKSHOP 3

Organized by **StevensWater & SoilMoisture**

Advances in Soil Water Movement Methods, in the Laboratory and in the Field

Tuesday 9th 18:00-19:00 (BAHIA Hall)

B. Keith Bellingham, *Soil Scientist at Stevens Water Monitoring Systems Inc. Portland, Oregon, United States*

Alan Farsad PhD., *Soil Scientist at SoilMoisture Equipment Corporation. Santa Barbara, California, United States*

Soil moisture plays a major role in food security, climate, flooding, wildfire management and many other environmental and geotechnical applications. Some examples include: soil moisture is monitored in the mountains in the western United States to determine river flow which in turn is used to forecast hydropower generation. Soil moisture monitoring can help assess landslides risks, flood risks and greenhouse gas sequestration in the soil. With so many processes being influenced by soil water content, it is important to understand soil water movement and methods for measurement and assessment. This is a technical course describing the nature of soil water movement with the latest laboratory and field technology. Topics include:

- Unsaturated hydraulic head, aka matric potential, soil tension, suction.
  - Tensiometers: how they work? Different types
- The soil water retention curve, laboratory determination and interpretation.
- Field and laboratory permeameters measuring saturated hydraulic conductivity.
- Soil moisture sensors portable and in situ.
- A short explanation of the complex dielectric permittivity for water content and salinity monitoring
- The Topp Equation, The Seyfried equation and other soil moisture/permittivity regressions.
- Darcy's Law, saturated soil water movement.
- The Richards Equation for variable unsaturated soil water flow
- A combined approach. Dielectric regression of a soil water retention curve for real time monitoring of soil moisture, unsaturated hydraulic head and hydraulic conductivity

EUROSOIL 2025 ASSOCIATIONS ASSEMBLIES

SECS General Assembly

9th September (18:00-20:00) (RONDA Hall)

ECSSS General Assembly

10th September (18:00-19:00) (RONDA Hall)

SOCIAL EVENTS WITHIN EUROSOIL 2025

Monday 8th	(19:00)	**Welcome Concert** at AL'ANDALUS Auditorium[1]
Monday 8th	(20:00)	**Spanish Wine** at the Dome in the venue[1]
Tuesday 9th	(09:30)	**Guided Tour Seville City Center** at "Puerta del León" Sevilla Alcazar[2]
Wednesday 10th	(20:30)	**Gala Dinner at Abades Triana**, Seville by the Guadalquivir River[3]
Thursday 11th	(13:45)	**Flamenco Taste** at AL'ANDALUS Auditorium[1]
Thursday 11th	(14:15)	**Farewell Party** at the Dome in the venue[1]

[1] For all registered participants and their accompanying persons.
[2] Only for accompanying persons.
[3] Only for participants and accompanying persons who have booked the event.

EUROSOIL 2025 TECHNICAL SECRETARIAT

VIAJES El Corte Inglés CONGRESOS

Ismael Castro
Alicia Fernández
Maribel Hernández
Manuel Balón Álvarez-Rementería

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ORGANIZED BY: ECSSS European Confederation of Soil Science Societies · SPCS · SECS Sociedad Española de la Ciencia del Suelo

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SCIENTIFIC PROGRAMME



SCIENTIFIC PROGRAMME

MONDAY 8th SEPTEMBER 2025

AL'ANDALUS Auditorium (Main Auditorium A, Ground floor)

09:00 - 10:00 — OPENING CEREMONY

Chairs:
José A. González-Pérez *(IRNAS-CSIC)* / **José Mª de la Rosa** *(IRNAS-CSIC)*

09:00 - 09:10 — **PRESENTATION OF EUROSOIL**

09:10 - 09:40 — OPENING CONFERENCE

Improving Soil Health in Europe: Emerging Challenges and Opportunities for Soil Science and Policy

Dr. Panos Panagos *(EC JRC, Ispra, Italy) (Presented by* **Dr. J. A. González-Pérez***)*

09:40 - 10:00 — INAUGURAL ACT

10:00 - 10:45 — **INAUGURAL LECTURE**

Soil Science and Global Issues of the 21st Century

Dr. Rattan Lal *(Ohio State Univ., USA)*

10:45 - 11:30 — COFFEE + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

11:30 - 13:00 — SESSION: GT09. SOIL HEALTH

Conceptual Frameworks & Assessment I

Chairs:
I. Ortíz-Bernard *(SECS President)* / **A. M. Paz** *(On behalf of SPCS President)*

11:30 - 11:45 — **ORAL 01:** **A. Mcbratney.** *Univ. Sydney (Australia)*
#664.
POSITIONING SOIL HEALTH WITHIN THE FRAMEWORK OF SOIL SECURITY.

11:45 - 12:00 — **ORAL 02:** **A. Reijneveld *et al.*** *Eurofins, Wageningen (The Netherlands)*
#578.
TURNING SOIL SCIENCE INTO ACTION: A PATHWAY TO ACHIEVE AGRICULTURAL SUSTAINABILITY IN LINE WITH THE SDGS.

12:00 - 12:15 — **ORAL 03:** **R. E. Zwaan *et al.*** *RIVM, Delft (The Netherlands)*
#206.
ARE ALL SOIL HEALTH SCORES QUANTIFIED EQUALLY? A SYSTEMATIC REVIEW, CLASSIFICATION AND COMPARISON OF SOIL HEALTH METHODOLOGIES.

12:15 - 12 - 30 — **ORAL 04:** **G. A. L. Riggi *et al.*** *Wageningen Env. Research (The Netherlands)*
#567.
TOWARDS ROBUST ASSESSMENT CRITERIA FOR SOIL BIOINDICATORS: INSIGHTS FROM EUROPEAN CASE STUDIES.



12:30 - 12:45 — **ORAL 05:** **G. Ross NIOO-KNAW,** *Wageningen (The Netherlands)*
#21.
SOIL MONITORING: STANDARDISED PROTOCOLS FOR THE ASSESSMENT OF BIODIVERSITY AND ECOSYSTEM SERVICES [SOIL HEALTH AND RE-EVALUATION; SHARE PROTOCOLS].

12:45 - 13:00 — **ORAL 06:** **C. Imbert *et al.*** *ZALF, Müncheberg (Germany)*
#266.
IDENTIFYING KEY STAKEHOLDERS IN SOIL MONITORING, REPORTING, AND VERIFICATION (MRV): AN OVERVIEW OF THE EARLY INSIGHTS.

13:00 - 14:30 — LUNCH + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 — SESSION: GT09. SOIL HEALTH

Carbon and Nutrient Cycling

Chairs:
P Hallett *(BSSS President)* / **A. Brauman** *(AFES President)*

14:30 - 14:45 — **ORAL 07:** **J. Fohrafellner *et al.*** *AGES, Vienna (Austria)*
#740.
META-ANALYSIS ON SOIL ORGANIC CARBON AND CEREAL PRODUCTION IN ORGANIC FARMING SYSTEMS ACROSS EUROPE.

14:45 - 15:00 — **ORAL 08:** **C. M. Rubeaud *et al.*** *Agroscope, Zürich (Switzerland)*
#533.
SECOND-ORDER META-ANALYSIS TO ASSESS THE GLOBAL EFFECTS OF AGROFORESTRY ON SOIL HEALTH.

15:00 - 15:15 — **ORAL 09:** **T. P. Duval.** *Univ. Toronto Mississauga (Canada)*
#830.
RACTIONS OF SEQUESTERED SOIL CARBON IN ABANDONED AGGREGATE PITS "RESTORED" TO GRASSLANDS.

15:15 - 15:30 — **ORAL 10. S. Chebet *et al.*** **ETH, Zurich (Switzerland)**
#18.
RAPID INCREASE IN SOIL ORGANIC CARBON AND STRUCTURAL STABILITY IN A SANDY LOAM SOIL FOLLOWING CONVERSION FROM LONG-TERM ARABLE TO SEMI-NATURAL GRASSLAND IRRESPECTIVE OF INITIAL SOIL CONDITIONS.

15:30 - 15:45 — **ORAL 11:** **A. R. Sánchez-Rodríguez *et al.*** *Univ. Córdoba (Spain)*
#230.
SOIL CARBON, FERTILITY, AND HEAVY METAL CONTENT UNDER DIRECT SOWING AND ORGANIC FARMING IN SPANISH RAINFED CEREALS.

15:45 - 16:00 — **ORAL 12:**
#TO BE CONFIRMED.

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16:00 - 16:30	**COFFEE + EXPO + POSTERS SESSION 1** **(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)**
19:00 - 21:00	**WELCOME CONCERT & SPANISH WINE**

MONDAY 8th SEPTEMBER 2025

ITALICA Auditorium (Auditorium B, First floor)

11:30 - 13:00 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

Circular Economy Approaches for Sustainable Crop Fertilization and Soil Health I

Chairs:
A. Delgado-García *(University of Seville)* / **V. A. Laudicina** *(Univ. of Palermo)*

11:30 - 11:45 — **ORAL 01:** **M. Mazzon *et al.*** *Univ. of Bologna (Italy)*
#309.
ORGANIC-BASED FERTILIZERS FOR SUSTAINABLE VINEYARD MANAGEMENT: EFFECTS ON SOIL BIOCHEMISTRY, MICROBIOME AND CARBON STOCK.

11:45 - 12:00 — **ORAL 02:** **P. F. Rupani *et al.*** *Cranfield Univ. (United Kingdom)*
#336.
ROOTED IN EMISSIONS: UNCOVERING GHG FLUXES FROM WINTER WHEAT UNDER ORGANO-MINERAL FERTILISATION.

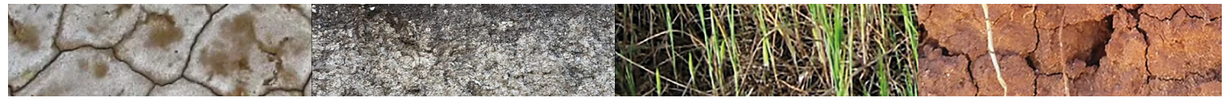
12:00 - 12:15 — **ORAL 03:** **M. Kamran *et al.*** *Univ. of Adelaide (Australia)*
#322.
REVITALIZING SANDY SOILS: ORGANO-MINERAL INPUTS ENHANCE DROUGHT RESILIENCE IN WHEAT AND MICROBES.

12:15 - 12:30 — **ORAL 04:** **N. A. Zahra *et al.*** *Technical Univ. Leoben (Austria)*
#86.
ENHANCING PLANT RESILIENCE TO DROUGHT: THE POTENTIAL OF CARBON FROM METHANE PLASMALYSIS (CMP)-BASED SOIL AMENDMENTS ASSESSED THROUGH PHENOTYPING.

12:30 - 12:45 — **ORAL 05:** **N. Kaloterakis *et al.*** *Agrosphere (IBG3), Jülich (Germany)*
#305.
MITIGATING YIELD DECLINE IN CONTINUOUS WINTER WHEAT ROTATIONS.

12:45 - 13:00 — **ORAL 06:** **S. M. Muscarella *et al.*** *Univ. of Palermo (Italy)*
#674:
A HOLISTIC APPROACH TO RECOVERY AND REUSE OF TREATED WASTEWATER AND ITS BY-PRODUCTS IN A CIRCULAR ECONOMY PERSPECTIVE: INSIGHTS FROM THE WIDER UPTAKE H2020 PROJECT.

13:00 - 14:30	**LUNCH + EXPO + POSTERS SESSION 1** **(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)**



14:30 - 16:30 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

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Circular Economy Approaches for Sustainable Crop Fertilization and Soil Health II

Chair:
C. Zaccone *(SISS President)* / **E. Madejón** *(IRNAS-CSIC)*

14:30 - 14:45 — **ORAL 07:** **R. Sakrabani *et al.*** *Cranfield Univ. (United Kingdom)*
#283.
EVALUATIN G INFLUENCE OF MOISTURE IN CONTROLLING RELEASE OF NUTRIENTS IN NOVEL GREEN FERTILISER USING NEUTRON IMAGING AND MUONIC X-RAYS.

14:45 - 15:00 — **ORAL 08:** **A. M. Robles *et al.*** *Univ. Santiago de Compostela (Spain)*
#143.
CHARACTERIZATION, TRANSFORMATION AND VALORIZATION OF AGRI-FOOD RESIDUES FROM STRATEGIC INDUSTRIES OF THE IBERIAN PENINSULA FOR SUSTAINABLE AGRICULTURE.

15:00 - 15:15 — **ORAL 09:** **B. Mod *et al.*** *The Univ. of Newcastle, Callaghan (Australia)*
#373.
POROUS BIOCARBON AS A SCAFFOLD FOR SLOW-RELEASE NITROGEN FERTILIZER.

15:15 - 15:30 — **ORAL 10:** **S. Boubehziz *et al.*** *Univ. Cordoba (Spain)*
#407.
PHOSPHORUS DYNAMICS AND PLANT RESPONSE WITH BIOAMENDMENTS IN CONTRASTING SOILS: INCUBATION EXPERIMENTS

15:30 - 15:45 — **ORAL 11:** **A. Boarino *et al.*** *Univ. di Torino (Italy)*
#589.
BALANCING NUTRIENTS IN LIVESTOCK-DERIVED FERTILIZERS TO REDUCE NUTRIENT LOSSES FROM AGRICULTURAL SOILS.

15:45 - 16:00 — **ORAL 12:** **V. Da Costa Oliveira *et al.*** *Inst. Politécnico de Coimbra (Portugal)*
#792.
FROM INVASIVE PLANT TO FERTILIZER: INDUSTRIAL-SCALE COMPOSTING OF WATER HYACINTH WASTE FOR SOIL IMPROVEMENT.

16:00 - 16:30	**COFFEE + EXPO + POSTERS SESSION 1** **(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)**

16:30 - 18:00 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

Circular Economy Approaches for Sustainable Crop Fertilization and Soil Health III

Chairs:
M. C. Horta *(IPCB)* / **R. López Núñez** *(IRNAS-CSIC)*

16:30 - 16:45 — **ORAL 13:** **M. Colomina-Garcia *et al.*** *Univ. de Lleida (Spain)*
#354.
IMPACT OF PIG SLURRY DIGESTATE ON SOIL QUALITY: A 6-YEAR STUDY.



16:45 - 17:00	**ORAL 14:**	**N. Matsumura *et al.*** *Meiji Univ.y, Kawasaki (Japan)*
	#473.	
	PHOSPHORUS RELEASE BEHAVIOR FROM SEWAGE SLUDGE MOLTEN SLAG AND ITS AVAILABILITY TO PLANT.	
17:00 - 17:15	**ORAL 15:**	**S. M. Pérez-Dalí *et al.*** *IRNAS-CSIC, Seville (Spain)*
	#475.	
	HARNESSING PYROLIGNEOUS ACID FOR CIRCULAR AGRICULTURE AND WEED MANAGEMENT.	
17:15 - 17:30	**ORAL 16:**	**Y. Chourak *et al.*** *Univ. of Vic (Spain)*
	#239.	
	DELISOIL: IMPROVING SOIL HEALTH BY TRANSFORMING FOOD INDUSTRY BY-PRODUCTS IN THE LIVING LAB OF CATALONIA.	
17:30 - 17:45	**ORAL 17:**	**H. Gwanyong.** *Gyeosang National Univ., Jinju (South Korea)*
	#285.	
	LIVESTOCK COMPOST APPLICATION AFFECTS TO CONVERTED UPLAND SOIL PHOSPHORUS CYCLING: ANALYSIS VIA P FRACTION.	
17:45 - 18:00	**ORAL 18:**	**J. O. Odhiambo *et al.*** *Univ. of Venda, Thohoyandou (South Africa)*
	#104.	
	MACADAMIA HUSK COMPOST HAS THE POTENTIAL TO IMPROVE SOIL QUALITY IN A MACADAMIA ORCHARD.	

19:00 - 21:00 **WELCOME CONCERT & SPANISH WINE**

MONDAY 8th SEPTEMBER 2025

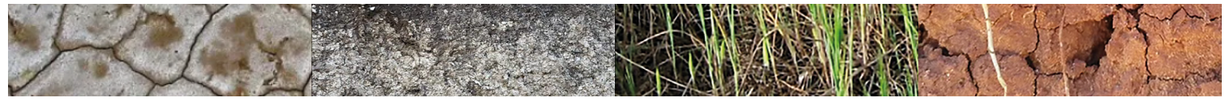
RONDA Hall (Auditorium C, First floor)

11:30 - 13:00 **SESSION: GT10. SOIL CARBON DYNAMICS & STABILIZATION**

Enhancing Soil Carbon through Sustainable Management for Climate Mitigation I

Chairs:
J. Aguilera Huertas *(Univ. Cordoba, Spain)* / **B. Lozano García** *(Univ. Cordoba, Spain)*
M. González Rosado *(Univ. Cordoba, Spain)*

11:30 - 11:45	**ORAL 01:**	**C. Fernández-Soler *et al.*** *CEBAS-CSIC, Murcia (Spain)*
	#619.	
	ROLE OF PLANT LITTER QUALITY ON CARBON SEQUESTRATION POTENTIAL IN RAINFED WOODY CROPS SYSTEMS.	
11:45 - 12:00	**ORAL 02:**	**Eugenia Gimeno-Garcia *et al.* CIDE (CSIC, UV, GVA), Moncada (Spain)**
	#267.	
	SOIL CARBON POOLS IN DIFFERENT SOIL TYPES MANAGED WITH PRESCRIBED FIRES IN THE VALENCIAN COMMUNITY.	
12:00 - 12:15	**ORAL 03:**	**A. P. Conte *et al.*** *Public Univ. of Navarra, Pamplona (Spain)*
	#319.	
	THE TWO FACES OF THE SOIL CARBON COIN: ORGANIC AND INORGANIC C DYNAMICS AS AFFECTED BY AGRICULTURAL MANAGEMENT IN CALCAREOUS SOILS.	



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12:15 - 12 - 30	**ORAL 04:**	**C- C. Pan and S- Y. Chen.** *Tainan Agric. Res. & Extension Station (Taiwan)*
	#112.	
	THE EFFECT OF SPONTANEOUS COVER CROP AND ORGANIC MANAGEMENT ON SOIL CARBON STOCK AND SOIL ORGANIC CARBON FRACTIONS IN POMELO ORCHARD IN TAIWAN.	
12:30 - 12:45	**ORAL 05:**	**C. Hernández-Moreno *et al.*** *Iberian Sustainable Mining Cluster, León (Spain)*
	#799.	
	SYNERGIES BETWEEN CARBON DIOXIDE REMOVAL (CDR) APPROACHES FOR ECOSYSTEM BENEFITS FROM SOIL-BASED, HIozanYBRID AND ENGINEERED METHODS.	
12:45 - 13:00	**ORAL 06:**	**S. Sushko *et al.*** *The Russian Academy of Sci., Pushchino (Russia)*
	#711.	
	THERMAL, PARTICLE-SIZE AND MICROBIAL-AVAILABLE POOLS OF SOIL ORGANIC MATTER IN TILLED AND NO-TILLED CHERNOZEMS.	

13:00 - 14:30 **LUNCH + EXPO + POSTERS SESSION1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 **SESSION: GT10. SOIL CARBON DYNAMICS & STABILIZATION**

Enhancing Soil Carbon through Sustainable Management for Climate Mitigation II

Chairs:
J. Aguilera Huertas *(Univ. Cordoba, Spain)* / **B. Lozano García** *(Univ. Cordoba, Spain)*
M. González Rosado *(Univ. Cordoba, Spain)*

14:30 - 14:45	**ORAL 07:**	**T. Bölscher *et al.*** *Univ. Paris-Saclay, INRAE, Palaiseau, (France)*
	#137.	
	LINKING CROP DIVERSIFICATION TO SOIL MICROBIAL DECOMPOSITION AND ORGANIC CARBON STORAGE – SYNTHESIS OF THE PAN-EUROPEAN EJP SOIL PROJECT ENERGYLINK.	
14:45 - 15:00	**ORAL 08:**	**M. Giordano *et al.*** *Univ. of Padua, (Italy)*
	#555.	
	SHORT-TERM EFFECT OF DIFFERENT AGRONOMIC MANAGEMENTS ON SOIL PARTICULATE ORGANIC MATTER (POM) AND MINERAL-ASSOCIATED ORGANIC MATTER (MAOM) CONTENT.	
15:00 - 15:15	**ORAL 09:**	**J. L. Nunes Carvalho *et al.*** *CNPEM/LNBR, Campinas (Brazil)*
	#813.	
	LAND USE INTENSIFICATION IN AMAZON REGION: IMPLICATIONS ON SOIL CARBON STORAGE AND STABILIZATION.	
15:15 - 15:30	**ORAL 10:**	**E. Grilli *et al.*** *Univ. of Campania "Luigi Vanvitelli", Caserta (Italy)*
	#152.	
	EFFECT OF LONG-TERM INCORPORATION OF CROP RESIDUES AND CONSERVATION TILLAGE ON SOIL ORGANIC CARBON STOCKS IN A MEDITERRANEAN FARMLAND UNDER DESERTIFICATION RISK: A 13C STUDY.	
15:30 - 15:45	**ORAL 11:**	**C. Poesio *et al.*** *Univ. of Perugia, (Italy)*
	#446.	
	EFFECTS OF COVER CROPS AND NO-TILLAGE ON SOIL ORGANIC MATTER DYNAMICS IN A MID-TERM FIELD EXPERIMENT.	
15:45 - 16:00	**ORAL 12:**	**G. Nascimento *et al.*** *Agrotecnio, Lleida (Spain)*
	#174.	
	WINTER COVER CROPS IMPROVE SOIL ORGANIC CARBON AND AGGREGATION IN MEDITERRANEAN RICE SYSTEMS.	



16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 18:00 — **SESSION: GT10. SOIL CARBON DYNAMICS & STABILIZATION**

Land Uses for Carbon Enhancement

Chair:
R. Kasparinskis *(Latvia Univ. of Life Sci. and Tech.)*

16:30 - 16:45 — **ORAL 13:** **A. Cervera-Mata *et al.*** *CEBAS-CSIC, Murcia (Spain)*
#236.
LONG-TERM SOIL CARBON LOSS AND GREENHOUSE GAS IMPACTS FROM FOREST CONVERSION TO AGRICULTURE IN MEDITERRANEAN SPAIN.

16:45 - 17:00 — **ORAL 14:** **A. R. Trindade *et al.*** *MED, Faro (Portugal)*
#816.
SOIL ORGANIC CARBON STORAGE IN CITRUS AND AVOCADO ORCHARDS.

17:00 - 17:15 — **ORAL 15:** **L.-P. Comeau *et al.*** *Agric. & Agri-Food Canada, Fredericton (Canada)*
#227.
INVESTIGATING THE INTERACTIONS AMONG SOIL CARBON, MICROBIAL DIVERSITY, AND LAND-USE MANAGEMENT..

17:15 - 17:30 — **ORAL 16:** **C. Mcmackin *et al.*** *Univ. of Zurich (Switzerland)*
#571.
FROM DEGRADATION TO STABILIZATION: ASSESSING MINERAL SOIL COVERAGE IN AGRICULTURAL PEATLAND MANAGEMENT.

17:30 - 17:45 — **ORAL 17:** **Z. Ott *et al.*** *Univ. Toulouse/CNRS/IRD/CNES, (France)*
#398.
STOCKS AND DYNAMICS OF PEDOGENIC CARBONATES IN ARID TROPICAL SOILS, COMPARISON BETWEEN IRRIGATED AGRICULTURE AND AGROFORESTRY.

17:45 - 18:00 — **ORAL 18:** **M. T. Karimi Nezhad *et al.*** *VUK, Brno (Czech Republic)*
#107.
SOIL CARBON AND NITROGEN DYNAMICS IN REWILDED EUROPEAN LANDS: INSIGHTS FROM META-ANALYSIS AND ISOTOPIC TRACERS.

18:00 - 19:00 — **WORKSHOP 1.** SOIL HEALTH INSTITUTE

Presenting "Slakes", a Free Smartphone App to Measure Aggregate Stability.

19:00:21:00 — **WELCOME CONCERT & SPANISH WINE**



MONDAY 8th SEPTEMBER 2025

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BAHIA Hall (Auditorium D, First floor)

11:30 - 13:00 — **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,**

ChairS:
M.R. Mosquera Losada *(Univ. Santiago de Compostela)* / **C. McMackin** *(Univ. Zurich)*

11:30 - 11:45 — **ORAL 01:** **C. Schillaci *et al.*** *JRC, Ispra (Italy)*
#690.
IMPROVING THE METHODOLOGY FOR THE UNCCD SDG 15.3.1 1 LAND DEGRADATION INDICATOR BASELINE ASSESSMENT IN THE EUROPEAN UNION.

11:45 - 12:00 — **ORAL 02:** **M. Ceacero-Moreno *et al.*** *Univ. Politécnica de Cartagena (Spain)*
#616.
SOIL MULTIFUNCTIONALITY ACROSS VEGETATION STRATA IN TECHNICALLY RESTORED AND SPONTANEOUSLY COLONIZED METALLIFEROUS MINE TAILINGS.

12:00 - 12:15 — **ORAL 03:** **D. Fernández-Rodríguez *et al.*** *Univ. de Extremadura, Badajoz (Spain)*
#724.
MODERATE AND SEVERE WATER-RESTRICTION IRRIGATION STRATEGIES AND BIOCHAR APPLICATION FOR THE CONTROL OF ARSENIC AND CADMIUM IN RICE FIELDS OF THE LOWER GUADIANA RIVER, MEDITERRANEAN REGION.

12:15 - 12:30 — **ORAL 04:** **F. Pearce**. *Lancaster Univ. (United Kingdom)*
#850.
DEGRADATION AND RESILIENCE OF SEMI-ARID GRASSLAND SOILS.

12:30 - 12:45 — **ORAL 05:** **L. Y. Maldonado.** *Univ. de Pamplona (Colombia)*
#153.
CADMIUM ADSORPTION CAPACITY OF COCOA POD HUSK BIOCHAR: A SUSTAINABLE MATERIAL FOR POTENTIAL SOIL REMEDIATION..

12:45 - 13:00 — **ORAL 06:** **J. M. Beck.** *Philipps Univ. Marburg (Germany)*
#349.
THE RISK OF SOIL SALINIZATION ALONG THE RIVER WERRA IN GERMANY AND ITS POTENTIAL IMPACT ON SOIL STRUCTURAL STABILITY..

13:00 - 14:30 — **LUNCH + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 — **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,**

Emerging Pollutants and Microplastics I

Chair:
L. Weihermüller *(FZ-Juelich)*

14:30 - 14:45 — **ORAL 07:** **S. Faure *et al.*** *CEA, Bagnols/cèze (France)*
#272.
NEW IRRIGATION PROCESS USING AQUEOUS FOAMS FOR SOIL TREATMENTS OR HEAP-LEACHING OF CRUSHED ORES.



14:45 - 15:00	**ORAL 08:**	**A. Míguez-González *et al.*** *Univ. de Santiago de Compostela, Lugo (Spain)*
	#241.	
	RISK ASSESSMENT OF THE PRESENCE OF IONOPHORE ANTIBIOTICS IN AGRICULTURAL SOILS BY MEANS OF THE LEUCINE INCORPORATION TECHNIQUE.	
15:00 - 15:15	**ORAL 09:**	**E. Loffredo *et al.*** *Univ. of Bari Aldo Moro (Italy)*
	#470.	
	POTENTIAL OF DIGESTATE-DERIVED VERMICOMPOST TO BEHAVE AS PESTICIDE ADSORBENT.	
15:15 - 15:30	**ORAL 10:**	**M. Pérez-López *et al.*** *Univ. de Extremadura, Badajoz (Spain)*
	#780.	
	INTEGRATED APPROACH OF ALTERNATE WETTING AND DRYING IRRIGATION WITH BIOCHAR AMENDMENT TO REDUCE CLOMAZONE HERBICIDE WATER POLLUTION IN RICE CULTIVATION.	
15:30 - 15:45	**ORAL 11:**	**Y. Liu *et al.*** *Ghent Univ. (Belgium)*
	#377.	
	MICROPLASTIC TRANSPORT IN SOIL BY NEMATODES.	
15:45 - 16:00	**ORAL 12:**	
	To be confirmed.	

16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 18:00 — **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,**

Emerging Pollutants and Microplastics II

Chairs:
E. Loffredo *(Univ. di Bari Aldo Moro)* / **D. Arenas-Lago** *(Univ. Vigo).*

16:30 - 16:45	**ORAL 13:**	**P. N. Kusumawardani *et al.*** *Ghent Univ. (Belgium)*
	#670.	
	THE REDISTRIBUTION OF PRISTINE AND AGED POLYSTYRENE MICROPLASTICS (<50 MM) IN SOIL AGGREGATE FRACTIONS.	
16:45 - 17:00	**ORAL 14:**	**F. López *et al.*** *Frontier Laboratories Europe, Essen (Germany)*
	#202.	
	QUANTIFICATION & IDENTIFICATION OF MICROPLASTICS IN MARINE SEDIMENTS BY PYROLYSIS-GC/MS..	
17:00 - 17:15	**ORAL 15:**	**M. Dia *et al.*** *Univ. of Angers (France)*
	#403.	
	TRACKING PFAS IN SOIL - DEVELOPMENT OF PFAS EXTRACTION METHOD AND ANALYSIS BY ELECTROCHEMICAL SENSORS DEVICE SPE-MIP VS HPLC.	
17:15 - 17:30	**ORAL 16:**	**L.V. Kiss *et al.*** *Hungarian Univ. of Agric. and Life Sci., Gödöllo (Hungary)*
	#291.	
	POLYPROPYLENE AND POLYESTER MICROFIBERS: A HIDDEN THREAT IN SOIL.	
17:30 - 17:45	**ORAL 17:**	**A. Bonetti *et al.*** *IRET-CNR, Florence (Italy)*
	#743.	
	FROM COMPOST TO SOIL CONTAMINATION: ASSESSING MICROPLASTICS IN FARMLAND USING ELUTRIATION.	
17:45 - 18:00	**ORAL 18:**	**L. Counet *et al.*** *Injectis, Barcelona (Spain)*
	#552.	
	IN-SITU PFAS STABILIZATION BY INJECTION OF ORGANO-CLAY (INSUFIX PROJECT)..	



18:00 - 19:00 — **WORKSHOP 2.** The British Society of Soil Science (BSSS)

Missions to Protect Soil

19:00 - 21:00 — **WELCOME CONCERT & SPANISH WINE**

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MONDAY 8th SEPTEMBER 2025

MARISMAS Hall (Auditorium E, First floor)

11:30 - 13:00 — **SESSION: GT02. SOIL PHYSICAL CHEMISTRY**

Soil Structure and Physical Modelling

Chair:
E. Micheli *(Hungarian Univ. Agric. And Life Sci.)*

11:30 - 11:45	**ORAL 01:**	**S. Chebet *et al.*** *Agroscope, Zurich (Switzerland)*
	#17.	
	TRACKING OF THREE-DIMENSIONAL SOIL STRUCTURE EVOLUTION UNDER TWO CONTRASTING LAND USES.	
11:45 - 12:00	**ORAL 02:**	**I. Kouera *et al.*** *Univ. Mohammed VI Polytechnic, Benguerir (Morocco)*
	#147.	
	DEVELOPING HIGH-PRECISION SOIL CEC MEASUREMENT FOR CANADIAN AND U.S. LABORATORIES: PEDOTRANSFER EQUATIONS, RAPID ROUTINES CHEMISTRY ANALYSIS, AND VIS–NIR/MIR SPECTROSCOPY.	
12:00 - 12:15	**ORAL 03:**	**A. M. Widmer *et al.*** *Agroscope, Zurich (Switzerland)*
	#185.	
	INFLUENCE OF PADDY RICE CULTIVATION ON CHEMICAL AND PHYSICAL PROPERTIES OF TWO CONTRASTING SOIL TYPES IN SWITZERLAND.	
12:15 - 12:30	**ORAL 04:**	**M. Kaspar.** *Univ. of Kaiserslautern-Landau, (Germany)*
	#422.	
	INTERSPECIFIC CHEMICAL VARIATION OF EARTHWORM MUCUS AND ITS INFLUENCE ON SOIL PHYSICOCHEMICAL PROPERTIES.	
12:30 - 12:45	**ORAL 05:**	**J. F. Miranda-Vélez Aarhus** *Univ., Viborg (Denmark)*
	#376.	
	20 YEARS OF NON-INVERSION TILLAGE AND STRAW RETENTION: EFFECTS ON YIELD AND FIELD NITROGEN IN THE CENTS LTE IN DENMARK.	
12:45 - 13:00	**ORAL 06:**	**L. Lin *et al.*** *Univ. of Liège, Liege (Belgium)*
	#253.	
	PREDICTING BULK DENSITY OF SOILS WITH VARYING DEGREE OF STRUCTURAL DEGRADATION USING SINGLE AND MULTI-PARAMETER BASED PEDOTRANSFER FUNCTIONS.	

13:00 - 14:30 — **LUNCH + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)



14:30 - 16:00	SESSION: GT02. SOIL PHYSICAL CHEMISTRY

Biogeochemical Cycles and Soil Contaminants

Chair:
F. Zehetner *(BOKU)*

14:30 - 14:45	**ORAL 07:** **M. Borisover** ***et al.*** *Inst. of Soil, Water and Environ. Sci., The Volcani Inst.,Rishon Lezion (Israel)* ***#105.*** ***HUMIC SUBSTANCES IN MOTION: DO THEY FORM A SUPRAMOLECULE OR UNDERGO ASSOCIATIVE-DISSOCIATIVE TRANSITIONS?***
14:45 - 15:00	**ORAL 08:** **R. E. Singh *et al.*** *Environ. Res. Centre, Teagasc Johnstown Castle, Wexford (Ireland)* ***#501.*** ***CHARACTERISING PEAT SOIL DIVERSITY ACROSS IRISH GRASSLANDS THROUGH PHYSICAL AND CHEMICAL INDICATORS.***
15:00 - 15:15	**ORAL 09:** **A. Parente-Sendín *et al.*** *Univ. de Vigo, Ourense (Spain)* ***#233.*** ***MERCURY IN THE SOIL-PLANT ECOSYSTEM OF A FOREST FROM THE UNESCO-BIOSPHERE RESERVE "AREA DE ALLARIZ" (NW IBERIAN PENINSULA).***
15:15 - 15:30	**ORAL 10:** **L. Acemel-Míguez *et al.*** *Univ. de Vigo, Orense (Spain)* ***#394.*** ***THE ROLE OF THE INVASIVE ACACIA DEALBATA IN SHAPING SOIL MERCURY POOLS IN NW SPAIN***
15:30 - 15:45	**ORAL 11:** **R. Bajouco *et al.*** *Univ. de Trás-os-Montes e Alto Douro, Vila Real (Portugal)* ***#472.*** ***PHOSPHORUS SORPTION IN MEDITERRANEAN SOILS: A COMPARATIVE MODELLING STUDY USING LANGMUIR, FREUNDLICH, AND SIP MODELS.***
15:45.16:00	**ORAL 12:** **M. Kochiieru.** *Vilnius Univ. (Lithuania)* ***#47.*** ***BULK DENSITY OF SOIL: DETERMINATION BY EXPRESS METHOD ON THE TERRITORY OF LITHUANIA..***

16:00 - 16:30	COFFEE + EXPO + POSTERS SESSION 1 (IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 17:00	FLASH ORAL SESSION GT01, GT11

Chair:
J. Notario del Pino *(Univ. La Laguna)*

16:30 - 16:35	**FLASH GT01-1:** **E. Pihlap *et al.*** *Centre of Estonian Rural Res. and Knowledge, Jõgeva (Estonia)* ***#295.*** ***MODERNIZING DIGITAL SOIL MAP OF ESTONIA USING GEOSPATIAL AND FIELD-BASED APPROACHES WITH THE FOCUS ON ORGANIC SOILS.***
16:35 - 16:40	**FLASH GT01-2:** **M. Tierra *et al.*** *EEAD-CSIC, Zaragoza (Spain)* ***#263:*** ***SALT-AFFECTED, GYPSUM, AND CARBONATE RICH SOILS UNDER THE COMMON AGRICULTURAL POLICY AND NEW IRRIGATION IN THE CENTRAL EBRO BASIN.***



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16:40 - 16:45	**FLASH GT01-3:** **S. Guerreiro *et al.*** *Univ. de Lisboa (Portugal)* ***#380.*** ***UPDATING SOIL MAPPING IN MEDITERRANEAN REGIONS THROUGH LANDSCAPE UNITS AND LEGACY SOIL DATA.***
16:45 - 16:50	**FLASH GT01-4:** **B. Dirnena *et al.*** *Univ. of Latvia, Riga (Latvia)* ***#435.*** ***SOIL FORMATION CONDITIONS, PROCESSES AND CLASSIFICATION ON THE BALTIC SEA COAST OF LATVIA.***
16:50 - 16:55	**FLASH GT01-5:** **Q. Peng.** *Univ. of Zurich (Switzerland)* ***#525.*** ***EVOLUTION OF SOILS IN THE NORTHEAST CHINA BLACK SOIL REGION: EVIDENCE FROM GEOCHEMISTRY.***
17:00 - 17:05	**FLASH GT11-1:** **J. Antunes *et al.*** *INIAV, Oeiras (Portugal)* ***#317.*** ***SPINACH MAINTAINS PRODUCTIVITY UNDER SALINE IRRIGATION AND ACHIEVESLONGER ROOTS.***
17:05 - 17:10	**FLASH GT11-2:** **D. Rossi *et al.*** *Univ. degli studi di Milano-Bicocca (Italy)* ***#400.*** ***FROM IMPACTED TO REUSABLE: DEFINING THE ECOLOGICAL POTENTIAL OF BIOREMEDIATED SOILS.***
17:10 - 17:15	**FLASH GT11-3:** **S. Singh *et al.*** *Material Res. Center, Jaipur (India)* ***#653.*** ***WHITE LIGHT EMISSION FROM A MIXTURE OF CARBON DOTS AND GOLD NANOCLUSTERS AND ITS APPLICATION FOR OPTICAL DETECTION OF HG2+ AND FE2+ IONS.***

19:00 - 21:00	WELCOME CONCERT & SPANISH WINE

MONDAY 8th SEPTEMBER 2025

MEZQUITA Hall (Auditorium F, First floor)

11:30 - 13:00	SESSION: GT05. SOIL HYDROLOY & EROSION

Chair:
B. Šarapatka *(CSSS President)*

11:30 - 11:45	**ORAL 01:** **P. Panagos *et al.*** *EC-JRC, Ispra (Italy)* ***#1137*** ***SOIL EROSION IN THE EU: A GROWING CONCERN FOR A SUSTAINABLE FUTURE.***
11:45 - 12:00	**ORAL 02:** **V. C. Steve Ubah. Federal Univ. of Technol. Owerri (Nigeria)** ***#258.*** ***THE HYDROLOGY AND SEDIMENT ANALYSIS AT SELECTED LOCATIONS OF IMO RIVER, IMO STATE, IN SOUTHEASTERN NIGERIA.***
12:00 - 12:15	**ORAL 03:** **D. U. Schwarze *et al.*** *Univ. of Hamburg (Germany)* ***#324.*** ***HOW SOIL ORGANIC MATTER, HYDROPHOBICITY AND HYSTERESIS INTERACT IN SANDY SOILS.***
12:15 - 12:30	**ORAL 04:** **A. Bargués-Tobella *et al.*** *Agrotecno - CERCA Center, Lleida (Spain)* ***#381.*** ***FIELD-SATURATED SOIL HYDRAULIC CONDUCTIVITY ACROSS SUB-SAHARAN AFRICA: FROM CONTINENTAL PATTERNS TO FILLING DATA GAPS IN GRASSY BIOMES.***



12:30 - 12:45	**ORAL 05:**	**B. Šarapatka** *and* **M. Bednar.** *Palacky Univ., Olomouc (Czech Republic)*
	#148.	
	DIFFERENTIAL EROSION PATTERNS IN CHERNOZEMS AND CAMBISOLS: IMPACT OF SLOPE MORPHOLOGY AND IMPLICATIONS FOR STRIP CROPPING DESIGN.	
12:45 - 13:00	**ORAL 06:**	**M. Horácek** *and* **B. Szabó.** *Univ. Ostrava (Czech Rep.) and Inst. Soil Sci., Budapest (Hungary)*
	#210.	
	PEDOTRANSFER FUNCTIONS FOR FOREST SOIL IN CZECHIA.	

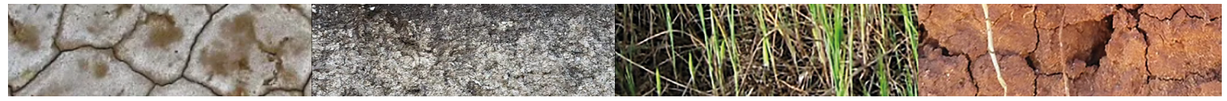
13:00 - 14:30 LUNCH + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 SESSION: GT12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANDSLIDES

Chair:
Jorge Mataix *(Univ. Miguel Hernández)*

14:30 - 14:45	**ORAL 01:**	**R. Ortega-Pérez *et al.*** *Univ. of Almería (Spain)*
	#116.	
	ASSESSMENT OF THE RESILIENCE OF MEDITERRANEAN SEMI-ARID SOILS TO LOW INTENSITY FIRES TO VALIDATE PRESCRIBED BURNING AS A WILDFIRE PREVENTION TOOL.	
14:45 - 15:00	**ORAL 02:**	**S. Negri *et al.*** *Univ. of Torino, Grugliasco (Italy)*
	#330.	
	POST-WILDFIRE CHANGES IN SOIL CHEMISTRY AND WATER REPELLENCY IN THE EUROPEAN ALPS: A MID-TERM CASE STUDY.	
15:00 - 15:15	**ORAL 03:**	**F. Scarciglia *et al.*** *Univ. della Calabria, Rende (Italy)*
	#430.	
	ARE SOIL FEATURES AND PEDOGENIC PROCESSES PREDISPOSING FACTORS OF SHALLOW LANDSLIDES? SOME RESULTS FROM THE ONGOING PROJECT SOIL SHADES.	
15:15 - 15:30	**ORAL 04:**	**P. Napoletano *et al.*** *Univ. of Florence (Italy)*
	#631.	
	SOIL RESPONSE TO MICROPLASTICS FOLLOWING WILDFIRE: INSIGHT FROM A SOIL COLUMN EXPERIMENT.	
15:30 - 15:45	**ORAL 05:**	**A. Girona-García *et al.*** *IMIB-CSIC-Univ. of Oviedo, Mieres (Spain)*
	#271.	
	THE ROLE OF POST-FIRE SOIL EROSION IN THE CARBON CYCLE	
15:45 - 16:00	**ORAL 06:**	**S. Vingiani *et al.*** *Univ. of Naples Federico II, Portici (Italy)*
	#414.	
	CHEMICAL SOIL PROPERTIES AND PEDOGENETIC INDICES AS KEY FACTORS TO IDENTIFY SOIL DISCONTINUITIES ACTING AS POTENTIAL FAILURE SURFACES OF SHALLOW LANDSLIDES IN A PILOT CATCHMENT OF THE CALABRIA REGION (SOUTHERN ITALY).	

16:00 - 16:30 COFFEE + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)



16:30 - 17:05 FLASH ORAL SESSION GT09

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Chair:
M. S. Rodríguez-Cruz *(IRNASA-CSIC)*

16:30 - 16:35	**FLASH GT09-1:**	**L. F. Bentley *et al.*** *UKCEH, Bangor (United Kingdom)*
	#160.	
	LESSONS FROM 5 DECADES OF NATIONAL SOILS MONITORING IN GREAT BRITAIN.	
16:35 - 16:40	**FLASH GT09-2:**	**M. Mazzon *et al.*** *Univ. of Bologna (Italy)*
	#308.	
	SOIL HEALTH IN DIFFERENT EXPERIMENTAL FIELDS: THE APPLICATION OF THE SOIL QUALITY INDEX AS AN INTEGRATED TOOL FOR SOIL MONITORING.	
16:40 - 16:45	**FLASH GT09-3:**	**R Daenen *et al.*** *Ghent Univ. (Belgium)*
	#346.	
	EFFECTS OF MINERAL NITROGEN FERTILIZATION ON SOIL HEALTH INDICATORS: A CASE STUDY FOR THE LONG-TERM BROADBALK EXPERIMENT.	
16:45 - 16:50	**FLASH GT09-4:**	**J. Bravo-García *et al.*** *Evenor-Tech, Sevilla (Spain)*
	#713.	
	SPATIOTEMPORAL MONITORING OF CARBON DYNAMICS AND TRACE ELEMENTS MODELLING IN-SITU AND EARTH OBSERVATION DATA.	
16:50 - 16:55	**FLASH GT09-5:**	**C. Ganilho *et al.*** *Univ. of Porto (Portugal)*
	#770.	
	SOIL HEALTH IN VINEYARDS: THE SENSITIVITY OF SOIL BIOLOGICAL INDICATORS TO MANAGEMENT PRACTICES AT QUINTA DO CASAL DA GRANJA, PORTUGAL.	
16:55 - 17:00	**FLASH GT09-6:**	**S. Godoy del Olmo.** *ENVISUELOS, Madrid (Spain)*
	#279.	
	SOIL QUALITY ASSESSMENT IN PARKS AND GARDENS OF VITORIA-GASTEIZ.	
17:00 - 17:05	**FLASH GT09-7:**	**A. Saari *et al.*** *Univ. of Helsinki (Finland)*
	#728.	
	IMPACTS OF REDUCED DITCH NETWORK MAINTENANCE ON ECOSYSTEM SERVICES OF PEATLAND FORESTS IN FINLAND.	

17:15 - 18:00 FLASH ORAL SESSION GT10

Chair:
F. Vanwindekens *(Centre wallon de rech. Agron., CRA-W)*

17:10 - 17:15	**FLASH GT10-1:**	**G. Nascimento *et al.*** *Agrotecnio, Lleida (Spain)*
	#174.	
	WINTER COVER CROPS IMPROVE SOIL ORGANIC CARBON AND AGGREGATION IN MEDITERRANEAN RICE SYSTEMS.	
17:15 - 17:20	**FLASH GT10-2:**	**G. Sumaila *et al.*** *Univ. College Dublin (Ireland)*
	#839.	
	EVALUATION OF DECISION SUPPORT TOOLS FOR THE ESTIMATION OF SOIL CARBON STOCK CHANGE UNDER SUSTAINABLE SOIL MANAGEMENT PRACTICES.	



17:20 - 17:25	**FLASH GT10-3:**	**E. Pihlap *et al.*** *Swedish Univ. of Agric. Sci., Uppsala (Sweden)*
	#605.	
	SOIL STRUCTURE FORMATION MEDIATED BY ORGANIC MATTER AND SHORT-RANGE ORDER ALUMINUM PHASES.	
17:25 - 17:30	**FLASH GT10-04:**	**L. B. Martínez-García *et al.*** *EEAD-CSIC, Zaragoza (Spain)*
	#564.	
	LEGUME COVER CROPS AND NON-TILLAGE ENHANCE SOIL MICROBIAL FUNCTIONAL DIVERSITY IN A SEMI-ARID BARLEY SYSTEM UNDER SUMMER RAIN PULSES.	
17:30 - 17:35	**FLASH GT10-5:**	**M. Ilyas *et al.*** *CREA, Rome (Italy)*
	#313.	
	ENHANCING CARBON SEQUESTRATION IN ITALIAN SOILS THROUGH REGENERATIVE AGRICULTURE: A REGIONAL COMPARATIVE STUDY.	

19:00 - 21:00 **WELCOME CONCERT & SPANISH WINE**

TUESDAY 9th SEPTEMBER 2025

AL'ANDALUS Auditorium (Main Auditorium A, Ground floor)

09:00 - 09:45 **PLENARY CONFERENCE**

Beneath the Surface, Beyond the Targets: Soil Carbon Science for EU Policies Development

Dr. Claire Chenu *INRAE-AgroParisTech, France* **(Presented by Dr. Rafael López-Núñez)**

09:45 - 11:00 **SESSION: GT09. SOIL HEALTH**

Management and Climate Strategies I

Chair:
C. Chenu *(INRAE-AgroParis Tech.)*

09:45 - 10:00	**ORAL 13:**	**I. Vogeler *et al.*** *Aarhus Univ., Tjele (Denmark)*
	#382.	
	SET-ASIDE LAND: A TOOL FOR SUSTAINABLE AGROECOSYSTEMS.	
10:15 - 10:30	**ORAL 14:**	**S. El Farricha *et al.*** *Bouygues Travaux Publics Région France, Paris (France)*
	#33.	
	REUSING EXCAVATED SOILS AND CONSTRUCTION MATERIALS TO RESTORE SOIL FUNCTIONALITY AND ENHANCE SUSTAINABILITY: A CROSS-DISCIPLINARY EXPERIMENTAL APPROACH AT CHALLENGER.	
10:30 - 10:45	**ORAL 15:**	**P. Napoletano *et al.*** *Univ. Florence (Italy)*
	#680.	
	GRAZING PRESSURE MEETS FOREST INTEGRITY: SOIL RESPONSE TO WILD UNGULATES IN THE SASSO FRATINO UNESCO INTEGRAL OLD-GROWTH FOREST (ITALY).	
10:45 - 11:00	**ORAL 16:**	**V. G. Correia *et al.*** *NOVA Univ. Lisbon, Caparica (Portugal)*
	#814.	
	PESTICIDE-CONTAMINATED SOILS: A TRIAD-BASED STRATEGY FOR SOIL HEALTH AND LAND RESTORATION.	



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11:00 - 12:00 **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

12:00 - 13:00 **SESSION: GT09. SOIL HEALTH**

Management and Climate Strategies II

Chair:
D. Sauer *(Univ. of Goettingen; DBG President)*

12:00 - 12:15	**ORAL 17:**	**O. Heller *et al.*** *Agroscope, Zürich (Switzerland)*
	#234.	
	SOIL MANAGEMENT IMPACTS ON SOIL STRUCTURAL PROPERTIES IN TEN EUROPEAN LONG-TERM EXPERIMENTS.	
12:15 - 12:30	**ORAL 18:**	**A. C. Royer *et al.*** *CIMO, LA SusTEC, Inst. Politécnico Bragança (Portugal)*
	#157.	
	IMPROVING SOIL HEALTH THROUGH NATURE-BASED SOLUTIONS: THE EFFECTS OF OLIVE-POMACE-BASED COMPOSTS.	
12:30 - 12:45	**ORAL 19:**	**C. Chiodi *et al.*** *Univ. Padova (Italy)*
	#756.	
	AGRIVOLTAIC PANEL SHADING ALTERS SOIL NUTRIENT DYNAMICS AND MICROBIAL COMMUNITIES.	
12:45 - 13:00	**ORAL 20:**	**M. S. Sümmerer *et al.*** *Inst. Agroecol. & Org. Farming; Freising (Germany)*
	#405.	
	IS ORGANIC FARMING A PATHWAY TO CLIMATE-RESILIENT SOILS?	

13:00 - 14:30 **LUNCH + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 **SESSION: GT09. SOIL HEALTH**

Monitoring Networks and Data Platforms

Chair:
J. Volungevičius *(LSSS President)* **/ A. McBratney** *(Univ, of Sydney)*

14:30 - 14:45	**ORAL 21:**	**L. R. Roder *et al.*** *Univ. degli Studi di Sassari (Italy)*
	#802	
	SOILS4MED SOIL MONITORING SYSTEM: DEVELOPING AN OPTIMIZED APPROACH FOR CAPTURING THE SOIL AND LANDSCAPE VARIABILITY OF THE MEDITERRANEAN REGION.	
14:45 - 15:00	**ORAL 22:**	**C. T. Omuto *et al.*** *Univ. Nairobi (Kenya)*
	#240.	
	THE AFRICA UNION SOIL OBSERVATORY (AUSO): A CONTINENTAL APPROACH TO SUPPORTING SOIL HEALTH AND AGRICULTURAL SUSTAINABILITY IN AFRICA.	
15:00 - 15:15	**ORAL 23:**	**F. J. Blanco-Velázquez *et al.*** *Evenor-Tech, Seville (Spain)*
	#712.	
	DIGITALISING SOIL HEALTH INVESTMENT BY DATA INTEGRATION FROM BUSINESS MODELS. THE CASE STUDY OF TAMARGUILLO PARK (SEVILLE, SPAIN) IN THE FRAMEWORK OF THE NOVASOIL PROJECT.	



15:15 - 15:30	**ORAL 24:**	**S. Shome *et al.*** *ZALF, Müncheberg (Germany)*
	#369.	
	REQUIREMENTS FOR DEVELOPING A FUTURE MONITORING, REPORTING, AND VERIFICATION (MRV) APPROACH FOR SOIL HEALTH: LESSONS LEARNED FROM THE FRENCH AND GERMAN NATIONAL SOIL MONITORING NETWORKS.	
15:30 - 15:45	**ORAL 25:**	**J. P. Martín-Sanz *et al.*** *IMIDRA, Madrid (Spain)*
	#.676	
	INFLUENCE OF COVER CROPS AND TILLAGE ON SOIL ENZYME ACTIVITY RATIOS OF VINEYARD SOILS IN A SEMI-ARID CLIMATE (SANCHOSTHIRST PROJECT).	
15:45 - 16:00	**ORAL 26:**	**B. K. Lankhorst.** *HAL24K Agri, Amsterdam (The Netherlands) & CEN/TC 444, Brussels (Belgium)*
	#507.	
	HARMONIZATION OF SOIL HEALTH DATA.	

16:00 - 16:30 **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 17:00 **SESSION:** **GT09. SOIL HEALTH**

Monitoring Networks and Data Platforms (Cont.)

Chair:
A. McBratney *(Univ, of Sydney)*

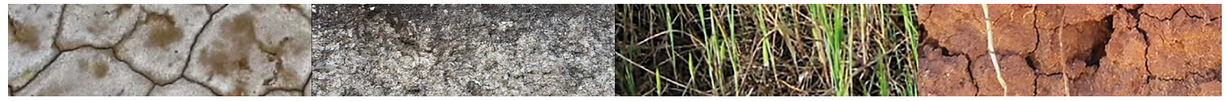
16:30 - 16:45	**ORAL 27:**	**M. R. Cherubin *et al.*** *Univ. São Paulo, Piracicaba (Brazil)*
	#181.	
	CENTER FOR CARBON RESEARCH IN TROPICAL AGRICULTURE (CCARBON): RESEARCH AND INNOVATIONS ON SOIL HEALTH.	
16:45 - 17:00	**ORAL 28:**	**V. Álvarez-López *et al.*** *Univ. A Coruña (Spain)*
	#520.	
	MONITORING SOIL FUNCTIONALITY IN TWO CROP TYPES -ANNUAL MAIZE AND PERENNIAL GRASSLAND- UNDER DIFFERENT AGRONOMIC MANAGEMENT PRACTICES.	

17:00 - 18:00 **SESSION:** **GT09. SOIL HEALTH**

Physical Structure and Hydrology

Chairs:
R. Ortega-Pérez *(Univ. Almería)* / **L. R. Roder** *(Univ. degli Studi di Sassari)*

17:00 - 17:15	**ORAL 29:**	**B. K. Bellingham.** *Stevens Water Monitoring Systems, Inc., Portland (United States)*
	#582.	
	SOIL WATER RETENTION CURVE USING A DIELECTRIC PERMITTIVITY REGRESSION	
17:15 - 17:30	**ORAL 30:**	**P. Davis *et al.*** *Clemson Univ. (USA)*
	#801.	
	CAN COVER CROPS INFLUENCE SOIL WATER REPELLENCY IN SOUTHERN UNITED STATES SOILS?	



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17:30 - 17:45	**ORAL 31:**	**E. L Rieke *et al.*** *Soil Health Institute, Morrisville (United States)*
	#783.	
	MEASURING AND INTERPRETING SOIL AGGREGATE STABILITY AT SCALE VIA SLAKING IMAGE ANALYSIS.	
17:45 - 18:00	**ORAL 32:**	**Y. Munetiko *et al.*** *Univ. A Coruña (Spain)*
	#171.	
	EFFECTS OF LAND USE, AGGREGATE SIZE AND SOIL DEPTH ON AGGREGATE STABILITY AND ENZYMATIC ACTIVITIES IN A SILVOPASTORAL SYSTEM.	
18:00 - 18:15	**ORAL 33:**	**F. M. Vanwindekens *et al.*** *Wallonie Recherche CRA-W, Gembloux, (Belgium)*
	#685.	
	THE QUANTISLAKETEST APPROACH FOR MEASURING SOIL STRUCTURAL STABILITY: INSIGHTS FROM NINE YEARS OF APPLICATION AND RECENT DEVELOPMENT.	

TUESDAY 9th SEPTEMBER 2025

ITALICA Auditorium (Auditorium B, First floor)

09:00 - 09:45 **PLENARY CONFERENCE**

Educating for a sustainable future: environmentally liveable, economically viable and humanly equitable

Dr. Laura Bertha Reyes Sánchez *(Universidad Nacional Autónoma de México)*
(Presented by Dr. Mª T. González-Domínguez)

09:45 - 11:00 **EUSO 5th Stakeholders Forum**

Chairs:
P. Panagos *(EC-JRC)*

09:45 - 10:00	**INTRODUCTORY SPEECH 1**	**by Dr. Arwyn Jones** *(EC-JRC)*
10:00 - 10:15	**ORAL 01:**	**J. S. Gutirrez-Díaz *et al.*** *Aarhus Univ., Foulum (Denmark)*
	#585.	
	DEVELOPING A BARE SOIL COMPOSITE TO IMPROVE SOIL ORGANIC CARBON MAPPING IN DENMARK.	
10:15 - 10:30	**ORAL 02:**	**P. Di Lonardo *et al.*** *Wageningen Univ.y and Res. (The Netherlands)*
	#443.	
	RETHINKING SOIL HEALTH IN URBAN SYSTEMS: INSIGHTS FROM RESEARCH TRENDS AND FIELD IMPLEMENTATION.	
10:30 - 10:45	**ORAL 03:**	**A. J. Manzaneda.** *Univ de Jaén (Spain)*
	#553.	
	DRIVERS OF SOIL HEALTH OF OLIVE GROVES AND THEIR IMPACT ON THE SUSTAINABLE PRODUCTION OF OLIVE OIL IN THE MEDITERRANEAN.	
10:45 - 11:00	**ORAL 04:**	**R. Giurgiu *et al.*** *Flanders Res. Inst. for Agric., Fish. & Food, Merelbeke-Melle (Belgium)*
	#575.	
	SOILWISE: ADVANCING A FAIR DATA AND KNOWLEDGE INFRASTRUCTURE FOR HEALTHIER SOILS IN EUROPE.	



11:00 - 12:00 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

12:00 - 13:00 EUSO 5th Stakeholders Forum

Chair:
P. Panagos *(EC-JRC)*

12:00 - 12:15 — **ORAL 05:** **P. Madejón *et al.*** *IRNAS-CSIC, Seville (Spain)*
#438.
MULTI-SCALE SPECTRAL MAPPING, RISK ASSESSMENT, AND PHYTOMANAGEMENT INNOVATIONS IN THE EDAPHOS PROJECT.

12:15 - 12:30 — **ORAL 06:** **R. Guiu-Sans *et al.*** *Eurecat, Centre Tecnològic de Catalunya, Tarragona (Spain)*
#389.
DEVELOPMENT AND OPTIMIZATION OF HIGHLY EFFECTIVE AND INNOVATIVE BIOSTIMULANT GRANULATES FORMULATIONS FOR HORTICULTURE.

12:30 - 12:45 — **ORAL 07:** **M.R. Mosquera-Losada *et al.*** *Univ. de Santiago de Compostela, Lugo (Spain)*
#459.
STRENGTHENING SUBSOIL HEALTH THROUGH SUS-SOIL FOR RESILIENT ECOSYSTEMS AND SUSTAINABLE LAND USE.

12:45 - 13:00 — **ORAL 08:** **J. Jonczak *et al.*** *Warsaw Univ. of Life Sci. (Poland)*
#192.
GRÓJEC LIVING LAB: CO-CREATION FOR SUSTAINABLE SOIL MANAGEMENT IN PRACTICE.

13:00 - 14:30 — **LUNCH + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 EUSO 5th Stakeholders Forum (cont)

Chair:
A. Jones *(EC-JRC)*

14:30 - 14:45 — **ORAL 09:** **D. Cammarano.** *Aarhus Univ., Tjele (Denmark)*
#442.
MULTI-FACETED BIODIVERSITY INTEGRATION FOR A HEALTHY SOIL AND RESILIENT CROP MANAGEMENT.

14:45 - 15:00 — **ORAL 10:** **D. M. Ribeiro *et al.*** *Food4Sustainability – Associação para a Inovação no Alimento Sustentável, Idanha-A-Nova (Portugal)*
#594.
THE LILAS4SOILS PROJECT: CARBON FARMING IN THE MEDITERRANEAN REGION

15:00 - 15:15 — **ORAL 11:** **A. Peiro *et al.*** *Ibercivis Foundation, Zaragoza (Spain)*
#235.
TOWARDS HEALTHIER SOILS THROUGH ECHO: CITIZEN ENGAGEMENT, PROGRESS AND PRELIMINARY RESULTS.

15:15 - 15:30 — **ORAL 12:** **J. A. Coblinski and G. Siebielec.** *Inst. of Soil Sci. and Plant Cultivation, Pulawy (Poland)*
#518.
NBSOIL ACADEMY: TRAINING SOIL ADVISORS TO PROMOTE SOIL HEALTH ACROSS EUROPE.



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15:30 - 15:45 — **ORAL 13:** **R. Pereira *et al.*** *GreenUPorto/INOV4Agro & Univ. of Porto (Portugal)*
#829.
CHALLENGES OF SOIL MONITORING AT LIVING LABS ON PERMANENT CROPS.

15:45 - 16:00 — **ORAL 14:** **F. Molinari *et al.*** *ANCI Toscana, Florence (Italy)*
#611.
FROM PILOTS CASES TO POLICIES: THE HUMUS PROJECT EXPERIENCE IN PARTICIPATORY SOIL GOVERNANCE

16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 19:00 SESSION: GT17.1. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE

Chairs:
C. Schillaci *(JRC Forest & bioeconomy, EU)* / **L. Sánchez-Álvarez** *(JRC Forest & bioeconomy, EU)*
P. Panagos *(EC-JRC Forest & bioeconomy, EU)*

16:30 - 16:45 — **ORAL 01:** **C. Schillaci *et al.*** *EC-JRC, Ispra (Italy)*
#763.
FROM EMPIRICAL TO REGRESSION-BASED PTF FOR THE CONVERSION OF 1:5 DILUTED ELECTRICAL CONDUCTIVITY TO SATURATED ECE.

16:45 - 17:00 — **ORAL 02:** **J. J. Jiménez *et al.*** *IPE-CSIC, Jaca (Spain)*
#205.
EFFECT OF ABANDONED RURAL SETTLEMENTS RESTORATION ON ECOSYSTEM SERVICES: TOWARDS A SUSTAINABLE ECOLOGICAL TRANSITION IN RURAL AREAS.

17:00 - 17:15 — **ORAL 03:** **K. Rau *et al.*** *Univ. of Tübingen (Germany)*
#220.
QUANTIFYING SPATIAL UNCERTAINTY TO IMPROVE THE PREDICTION OF SOIL PROPERTIES IN DATA-SPARSE REGIONS.

17:15 - 17:30 — **ORAL 04:** **R. Lang *et al.*** *Swedish Univ. of Agric. Sci., Uppsala (Sweden)*
#340.
LAND COVER CLASSIFICATION EFFECT ON SOIL MONITORING: A COMPARATIVE ANALYSIS OF LUCAS AND SWEDISH NATIONAL INVENTORY ON AGRICULTURAL SOILS.

17:30 - 17:45 — **ORAL 05:** **G. Winkler and T. Pinto-Correia.** *Univ. of Ferrara (Italy) & Univ. of Evora (Portugal)*
#386.
UNVEILING PLURAL VALUES IN SOIL MANAGEMENT: A CASE STUDY FROM THE MONTADO AGRO-SILVO-PASTORAL SYSTEM IN PORTUGAL.

17:45 - 18:00 — **ORAL 06:** **C. Chartin *et al.*** *Walloon Agric. Res. Centre, Gembloux (Belgium)*
#503.
TRACKING SOIL PROPERTIES CHANGES FROM LEGACY SURVEY TO MODERN MONITORING SYSTEMS THROUGH SPATIAL ANALYSIS – CASE OF WALLONIA, SOUTHERN BELGIUM.

18:00 - 18:15 — **ORAL 07:** **I. Ortiz-Bernad *et al.*** *Univ. of Granada (Spain)*
#574.
GRANADA TIERRA VIVA: MAPPING SOIL ISSUES IN SOUTHWEST EUROPE.



18:15 - 18:30	**ORAL 08:**	**F. Yunta *et al.*** *EC-JRC, Ispra (Italy)*
	#746.	
	SOLACE PROJECT: UNDERSTANDING THE LINKS BETWEEN SOIL POLLUTION AND CANCER IN EUROPE.	
18:30 - 18:45	**ORAL 09:**	**P. Zdruli *et al.*** *CIHEAM Medit. Agron. Inst. of Bari, Valenzano (Italy)*
	#71.	
	THE ROLE OF EU SOIL DEAL FOR EUROPE MISSION AND SOILS4MED PROJECT TO PROMOTE SOIL HEALTH.	
18:45 - 19:00	**ORAL 10:**	**X. Rotllan-Puig *et al.*** *LifeWatch ERIC, Seville (Spain)*
	#771.	
	EMPOWERING SOIL RESEARCH THROUGH VIRTUAL RESEARCH ENVIRONMENTS: LIFEWATCH ERIC SERVICES UNDER THE AGROSERV AND SUS-SOIL PROJECTS.	

TUESDAY 9th SEPTEMBER 2025

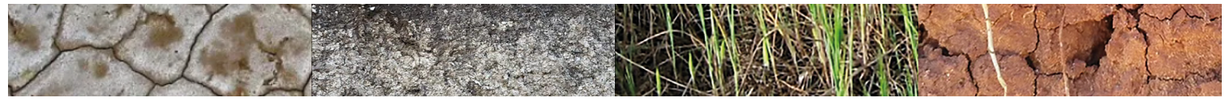
RONDA Hall (Auditorium C, First floor)

09:45 - 11:00 — SESSION: GT10. SOIL C DYNAMICS & STABILIZATION

Carbon Characterization at the Pedon to Micro Scale, and Linking to the Landscape Scale I

Chair:
S. O'Rourke *(Univ. College Dublin)*

09:45 - 10:00	**ORAL 19:**	**W. Zhao *et al.*** *OGU, Univ. of Bristol (United Kingdom)*
	#75.	
	MONITORING UPTAKE OF ROOT-DERIVED CARBON INTO THE SOIL CARBON POOL AND MICROBIAL COMMUNITY USING STABLE ISOTOPE PROBING OF VOLATILE ORGANIC COMPOUNDS (SIP-VOC) AND SIP-PLFA ANALYSIS.	
10:00 - 10:15	**ORAL 20:**	**A. C. Somenahally *et al.*** *Texas A&M Univ., Overton (USA)*
	#453.	
	ADVANCING MODELS FOR ESTIMATING SOIL ORGANIC CARBON DEFICITS USING LEGACY-DATA-DRIVEN DYNAMIC BASELINE AND ATTAINABLE PROJECTIONS.	
10:15 - 10:30	**ORAL 21:**	**C. O'Connor *et al.*** *Swedish Univ. Agricultural Scie., Uppsala (Sweden)*
	#549.	
	PARAMETRIZATION OF SOIL ORGANIC CARBON MODELS CONSTRAINED BY 12C, 13C AND 14C SIGNATURES USING DATA FROM A LONG-TERM FIELD EXPERIMENT.	
10:30 - 10 : 45	**ORAL 22:**	**M. Möller *et al.*** *Thünen Inst. Forest Ecosy., Eberswalde (Germany)*
	#274.	
	SPATIAL PATTERNS OF SOIL ORGANIC CARBON IN GERMAN FORESTS: APPLICATION OF RANDOM FORESTS FOR DIGITAL SOIL MAPPING.	
10:45 - 11:00	**ORAL 23:**	**A. Ehlinger *et al.*** *Univ. of Turin, Grugliasco (Italy)*
	#432.	
	SHIFTS IN MICROBIAL CUE AS A FUNCTION OF AVAILABLE ORGANIC C RESOURCES AND ELECTRON ACCEPTORS UNDER CHANGING SOIL REDOX CONDITIONS.	



11:00 - 12:00 — COFFEE + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

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12:00 - 13:00 — SESSION: GT10. SOIL C DYNAMICS & STABILIZATION

Carbon Characterization at the Pedon to Micro Scale, and Linking to the Landscape Scale II

Chair:
G. Abbott *(Newcastle University)*

12:00 - 12:15	**ORAL 24:**	**O. Ozkiper *et al.*** *Aarhus Univ., Tjele (Denmark)*
	#175.	
	ENHANCING SOC MODEL PERFORMANCE FOR CARBON FARMING USING LONG-TERM EXPERIMENTS.	
12:15 - 12:30	**ORAL 25:**	**A. Gorbacheva *et al.*** *HSE Univ., Moscow (Russia)*
	#669.	
	ORGANIC CARBON SEQUESTRATION POTENTIAL OF RUSSIAN CHERNOZEMS: A COMPARATIVE STUDY OF NET PRIMARY PRODUCTION METHODS.	
12:30 - 12:45	**ORAL 26:**	**C. A. Torres Guerrero *et al.*** *Beta Tech Centre, UVIC-UCC, Vic (Spain)*
	#409.	
	ADVANCING MEDITERRANEAN CARBON FARMING THROUGH DIGITAL TOOLS AND PREDICTIVE MODELLING..	
12:45 - 13:00	**ORAL 27:**	**J. Brzozon *et al.*** *Albert-Ludwigs-Univ. Freiburg (Germany)*
	#560.	
	SPATIO-TEMPORAL CONTROLS OF SOIL RESPIRATION IN A MIXED FOREST IN THE SOUTHWESTERN FOOTHILLS OF THE BLACK FOREST (GERMANY).	

13:00 - 14:30 — LUNCH + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 — SESSION: GT10. SOIL C DYNAMICS & STABILIZATION

Management Practices and Soil Health

Chair:
R. M. Poch *(Univ. Lleida)*

14:30 - 14:45	**ORAL 28:**	**A. Zhartybayeva *et al.*** *Aarhus Univ., Tjele (Denmark)*
	#176.	
	THE QUALITY OF ORGANIC MATTER INPUT AFFECTS THE DECOMPOSITION OF SOC: EVIDENCE FROM A C3-TO-C4 CONVERSION EXPERIMENT.	
14:45 - 15 : 00	**ORAL 29:**	**L. F. Bentley *et al.*** *UKCEH, Bangor (United Kingdom)*
	#159.	
	FIRST SIGNS THAT NATIONAL CROPLAND ORGANIC CARBON LOSS IS REVERSING IN BRITISH TOPSOILS.	
15:00 - 15:15	**ORAL 30:**	**J. Heinonsalo.** *Univ. of Helsinki (Finland)*
	#326.	
	FROM PROCESS STUDIES TO FIELD TRIALS: LESSONS LEARNED FROM C FARMING EXPERIMENTATION IN FINLAND.	



15:15 - 15:30	**ORAL 31:**	**A. M. Castellon Meyrat *et al.*** *EAGASC, Johnstown Castle, Wexford (Ireland)*
	#298.	
	IMPACT OF MANAGEMENT INTENSITY OF AGRICULTURAL SYSTEMS ON SOIL ORGANIC CARBON STOCKS.	
15:30 - 15:45	**ORAL 32:**	**N. Blaesbjerg**. *Univ. of Tasmania, Hobart (Australia)*
	#91.	
	EFFECTS OF WARMING ON SOIL CARBON STORAGE AND SOIL STRUCTURAL STABILITY – A CASE STUDY FROM THE TASMANIAN HIGHLANDS.	
15:45 - 16:00	**ORAL 33:**	**A. Skersiene and A. Šlepetiene.** *Lithuanian Res. Centre Agric. & Forestry (Lithuania)*
	#51.	
	SOC ACCUMULATION TRENDS IN LONG-TERM MONOCULTURE POACEAE SWARDS.	

16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 18:00 — **SESSION: GT10. SOIL C DYNAMICS & STABILIZATION**

Effects of Soil C Content in Soil Health

Chair:
Ian Bull *(Bristol University)*

16:30 - 16:45	**ORAL 34:**	**Z. Ghasemzadeh *et al.*** *The Univ. of Adelaide, Adelaide (Australia)*
	#423.	
	FE-MEDIATED STABILISATION OF RHIZODEPOSITED CARBON AND ITS INFLUENCE ON SOIL STRUCTURE IN POORLY STRUCTURED SOILS.	
16:45 - 17:00	**ORAL 35:**	**T. Kätterer & M. A. Bolinder.** *Swedish Univ. Agric. Sci., Uppsala (Sweden)*
	#261.	
	IMPROVED SOIL STRUCTURE ALONG A GRADIENT OF SOIL ORGANIC C CONTENT IDENTIFIED AS THE MAIN DRIVER OF YIELD AND YIELD STABILITY RESPONSES.	
17:00 - 17:15	**ORAL 36:**	**M. Molina-Roco *et al.*** *Univ. de Los Lagos, Osorno (Chile)*
	#823.	
	HUMIC SUBSTANCES FOR AMELIORATING AL TOXICITY OF BARLEY GENOTYPES IN AN ANDISOL.	
17:15 - 17:30	**ORAL 37:**	**M. Mdaini *et al.*** *ETSI, Univ. Politéc. de Cartagena (Spain)*
	#323.	
	SOIL ORGANIC CARBON DYNAMICS UNDER INCREASED SALINITY AND TEMPERATURE IN SEMIARID IRRIGATED SOILS.	
17:30 - 17:45	**ORAL 38:**	**S. M. O'Rourke *et al.*** *Univ. College Dublin (Ireland)*
	#797.	
	EFFECT OF MINIMUM TILLAGE AND NUTRIENT SUPPLEMENTATION TO INCORPORATED STRAW AND THEIR IMPACT ON SOIL ORGANIC MATTER AND STRUCTURE.	
17:45 - 18:00	**ORAL 39:**	**S. M. O'Rourke *et al.*** *Univ. College Dublin (Ireland)*
	#854.	
	DEVELOPMENT OF AN AUTOMATED NDIR-BASED SYSTEM FOR CO_2 SOIL FLUX ANALYSIS..	

18:00 - 20:00 — **Spanish Society of Soil Sciences (SECS) GENERAL ASSEMBLY**



TUESDAY 9th SEPTEMBER 2025

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BAHIA Hall (Auditorium D, First floor)

09:45 - 11:00 — **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,…**

Digital Tools and Monitoring

Chair:
R. Millán-Gómez *(CIEMAT)*

09:45 - 10:00	**ORAL 19:**	**S. Pindral *et al.*** *Inst. of Soil Sci. and Plant Cultivation - State Res. Inst., Pulawy, (Poland)*
	#810.	
	INTEGRATION OF DIGITAL SOIL AND CROP HEALTH MONITORING SYSTEM: A COMBINED APPROACH FROM THE WHEATWATCHER PROJECT – A CASE STUDY OF SILESIA REGION.	
10:00 - 10:15	**ORAL 20:**	**M. J. Márques *et al.*** *Univ. Autónoma de Madrid (Spain)*
	#572.	
	TARGETING AGRICULTURAL SOIL RECOVERY THROUGH LONG-TERM COVER CROPS IN MEDITERRANEAN WOODY CROPS: IMPACTS ON ORGANIC MATTER AND WATER AVAILABILITY.	
10:15 - 10:30	**ORAL 21:**	**J. Ivelic-Sáez *et al.*** *Univ. Austral de Chile, Punta Arenas (Chile)*
	#357.	
	SOIL PHYSICAL RESPONSES TO GRAZING AND VEGETATION HETEROGENEITY IN THE PATAGONIAN STEPPE: ASSESSING DEGRADATION AND RESILIENCE AT MULTIPLE SPATIAL SCALES.	
10:30 - 10 - 45	**ORAL 22:**	**L. Cáceres-Jensen *et al.*** *Univ. Metropolitana de Ciencias de Educación, Santiago (Chile)*
	#922.	
	INTEGRATING CHEMOINFORMATIC AND MULTIVARIATE VOLCANIC ASH-DERIVED SOILS DATA MODELLING TO EXPLORE THE CHEMICAL SPACE OF SULFONYLUREA ADSORPTION.	
10:45 - 11:00	**ORAL 23:**	
	To be confirmed.	

11:00 - 12:00 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

12:00 - 13:00 — **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,…**

Amendments and Soil Remediation

Chairs:
A. Karczewska *(Wroclaw Univ.)* / **S. Norra** *(Univ. Karlsruhe)*

12:00 - 12:15	**ORAL 24:**	**P. Alvarenga *et al.*** *Univ. of Lisbon (Portugal)*
	#831.	
	USE OF BIOMASS ASHES AND PAPER-MILL BIOLOGICAL SLUDGES IN THE REMEDIATION OF PYRITE MINE-CONTAMINATED SOILS: RESULTS FROM A 2-YEARS PILOT PLOT EXPERIMENT.	



12:15 - 12:30	**ORAL 25:**	**T. Gentil *et al.*** *Univ. Montpellier, Marcoule, Bagnols-Sur-Cèze (France)*
	#222.	
	AQUEOUS FOAM GENERATED IN SITU FOR TOP SOIL REMEDIATION.	
12:30 - 12:45	**ORAL 26:**	**B. Fernandes *et al.*** *GreenUPorto/INOV4Agro, (Portugal)*
	#621.	
	THE USE OF FOREST AND FOOD WASTES TO MITIGATE Cu CONTAMINATION IN VINEYARD SOILS.	
12:45 - 13:00	**ORAL 27:**	**A. Sánchez-Poyal *et al.*** *INDUROT, Univ. of Oviedo (Spain)*
	#304.	
	ARTIFICIAL SOILS AS A PROMISING CDR AND LAND RESTORATION STRATEGY.	

13:00 - 14:30 **LUNCH + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

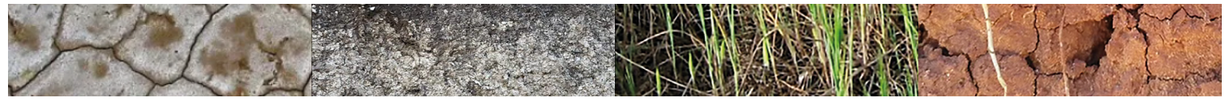
14:30 - 16:00 **SESSION: GT11. SOIL DEGRADATION, DESERTIFICATION,…**

Phytoremediation

Chair:
P. Alvarenga *(ISA, Univ. Lisbon)*

14:30 - 14:45	**ORAL 28:**	**J. J. Ortega-Calvo *et al.*** *IRNAS-CSIC, Seville (Spain)*
	#602.	
	RISK-BASED DESIGN OF BIOREMEDIATION IN HYDROCARBON CONTAMINATED SITES TO DELIVER RESILIENT SOILS: BIOAVAILABILITY.	
14:45 - 15:00	**ORAL 29:**	**S. Maletic *et al.*** *Univ. Novi Sad (Serbia)*
	#573.	
	SUSTAINABLE REMEDIATION OF DREDGED SEDIMENTS WITH ENERGY CROPS TARGETING ORGANIC CONTAMINANTS.	
15:00 - 15:15	**ORAL 30:**	**A. L.- H. Sahraoui *et al.*** *Univ. du Littoral Côte d'Opale (ULCO), Calais (France)*
	#38.	
	PHYTOMANAGEMENT OF A TRACE ELEMENT-CONTAMINATED AGRICULTURAL SOIL USING AROMATIC AND MEDICINAL PLANTS TO PRODUCE ESSENTIAL OILS.	
15:15 - 15:30	**ORAL 31:**	**A. Fernández-Guerrero *et al.*** *CEBAS-CSIC, Murcia (Spain)*
	#719.	
	STRESS RESPONSE OF BRASSICA JUNCEA AND SORGHUM BICOLOR TO POTENTIALLY TOXIC ELEMENTS PRESENT IN CONTAMINATED SOIL.	
15:30 - 15:45	**ORAL 32:**	**K.-D. Seydou *et al.*** *Earth and Life Inst., UCLouvain, Louvain-La-Neuve (Belgium)*
	#544.	
	DO CONSERVATION AGRICULTURE PRACTICES IMPROVE SOIL QUALITY AND CROP PRODUCTIVITY? APPLICATION TO COTTON-MAIZE SYSTEMS IN NORTHERN BENIN.	
15:45 - 16:00	**ORAL 33:**	**M. K. Isakovski *et al.*** *Univ. Novi Sad (Serbia)*
	#671.	
	PHYTOREMEDIATION OF TPH-CONTAMINATED SOIL USING HEMP AND SORGHUM.	

16:00 - 16:30 **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)



16:30 - 18:00 **SESSION: GT11.3. SOIL DEGRADATION, DESERTIFICATION, …**

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Chairs:
A. Molinero García *(Univ. Huelva)* **/ A. Gómez-Arias** *(IRNAS-CSIC)*
R. Millán Becerro *(Univ. Granada).*

16:30 - 16:45	**ORAL 34:**	**M. Pietrzykowski *et al.*** *Univ. of Krakow (Poland)*
	#88.	
	CHANGES IN THE TECHNOSOLS PROPERTIES FOLLOWING THE AFFORESTATION OF CARBONIFEROUS PARENT ROCK MATERIAL ON THE POST-HARD COAL MINING SPOIL HEAP.	
16:45 - 17:00	**ORAL 35:**	**R. Zornoza *et al.*** *Univ. Politéc. de Cartagena (Spain)*
	#95.	
	IMPROVEMENT OF SOIL HEALTH AND BIODIVERSITY THROUGH THE CREATION OF TECHNOSOLS IN TAILINGS PONDS.	
17:00 - 17:15	**ORAL 36:**	**A. Aguilar-Garrido *et al.*** *ETSIA., Tech. Univ. of Cartagena (Spain)*
	#529.	
	CONSTRUCTED TECHNOSOLS ENHANCE BARLEY GROWTH AND REDUCE METAL UPTAKE IN POLLUTED SOILS.	
17:15 - 17:30	**ORAL 37:**	**L. Uzarowicz *et al.*** *Warsaw Univ. of Life Sci., SGGW (Poland)*
	#221.	
	WEATHERING OF ARSENOPYRITE IN TECHNOSOLS ON THE STORCZYKOWA MINE DUMP NEAR THE HISTORICAL ARSENIC AND GOLD MINE IN ZŁOTY STOK, SUDETY MTS. SW POLAND AND ITS IMPLICATIONS FOR SOIL CONTAMINATION WITH TOXIC TRACE ELEMENTS.	
17:30 - 17:45	**ORAL 38:**	**A. Karczewska *et al.*** *Wroclaw Univ. of Environ.and Life Sci. (Poland)*
	#791.	
	LEGAL REQUIREMENTS AND REMEDIATION STATUS OF THE SITES CONTAMINATED WITH TOXIC ELEMENTS – THE EXAMPLE OF SOILS POLLUTED WITH COPPER IN POLAND.	
17:45 - 18:00	**ORAL 39:**	**L. A. Mansour *et al.*** *Mohammed 6 Polytech. Univ., Benguerir (Morocco)*
	#281.	
	ASSESSMENT OF SPATIAL AND VERTICAL DISTRIBUTION OF HEAVY METALS IN AGRICULTURAL SOILS OF MIDLAND MOROCCO: ECOLOGICAL AND HEALTH RISK IMPLICATIONS.	

18:00 - 19:00 **WORKSHOP 3.** STEVENS + SOIL MOISTURE

Advances in Soil Water Movement Methods, in the Laboratory and in the Field



TUESDAY 9th SEPTEMBER 2025

MARISMAS Hall (Auditorium E, First floor)

09:45 - 11:00 — SESSION: GT01. SOIL GENESIS, EVOLUTION & CLASSIFICATION

Soil Genesis, Properties, and Classification Challenges

Chair:
D. Badía *(Univ. Zaragoza)*

09:45 - 10:00	**ORAL 01:**	**J. S. Deckers *et al.*** *KU Leuven, Winksele (Belgium)*
	#6.	
	ANTHROSOLS REVISITED.	
10:00 - 10:15	**ORAL 02:**	**T. Magiera *et al.*** *Inst. of Environ. Eng., Polish Acad. Sci., Zabrze (Poland)*
	#228.	
	IS MAGNETIC SUSCEPTIBILITY USEFUL IN FOREST SOIL CLASSIFICATION?	
10:15 - 10:30	**ORAL 03:**	**P. Sowinski *et al.*** *Univ. of Warmia and Mazury in Olsztyn (Poland)*
	#688.	
	THE NEED TO UPDATE POLISH SOIL MAPS IN THE CONTEXT OF TRANSFORMATIONS OF ORGANIC SOILS.	
10:30 - 10 - 45	**ORAL 04:**	**R. Kasparinskis *et al.*** *Univ. of Latvia, Riga (Latvia)*
	#514.	
	POSTGLACIAL AGRICULTURAL LANDSCAPE SOILS - GENESIS, CLASSIFICATION AND MAPPING.	
10:45 - 11:00	**ORAL 05:**	**E. Z. Dobos *et al.*** *Univ. of Miskolc (Hungary)*
	#824.	
	SOIL FORMING ENVIRONMENT AND GENESIS OF THE WORLD SOIL OF THE YEAR 2025 – A GLEYSOIL FROM THE CARPATHIAN-BASIN.	

11:00 - 12:00 — COFFEE + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

12:00 - 13:00 — SESSION: GT01. SOIL GENESIS, EVOLUTION & CLASSIFICATION

Soils Though Time: From the Past to the Future I

Chairs:
F. Scarciglia *(Univ. Calabria)* / **F. Kurbanova** *(Inst. Geography RAS)*

12:00 - 12:15	**ORAL 06:**	**T Vanwalleghem.** *Univ. de Córdoba (Spain)*
	#526.	
	TOWARDS THIRD GENERATION SOIL FORMATION MODELS.	
12:15 - 12:30	**ORAL 07:**	**H. Zhen Hum and Z.-Y.** *Hseu. National Taiwan Univ., Taipei (Taiwan)*
	#28.	
	SIGNATURE AND FRACTIONATION OF RARE EARTH ELEMENTS IN SOIL CARBONATE NODULES ALONG A CHRONOSEQUENCE IN TAIWAN.	



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12:30 - 12:45	**ORAL 08:**	**P. Vidal-Torrado *et al.*** *Univ. of São Paulo, Piracicab (Brazil)*
	#191.	
	PEATLAND FORMATION AND COASTAL PLAIN EVOLUTION IN SOUTHEASTERN BRAZIL: UNRAVELING THEIR INTERCONNECTIONS.	
12:45 - 13:00	**ORAL 09:**	**F. Zehetner *et al.*** *BOKU Univ., Vienna (Austria)*
	#379.	
	TEMPORAL EVOLUTION OF BIOSPHERIC AND WEATHERING-INDUCED C DRAWDOWN ALONG A ONE-MILLION-YEAR SOIL CHRONOSEQUENCE.	

13:00 - 14:30 — LUNCH + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 — SESSION: GT01. SOIL GENESIS, EVOLUTION & CLASSIFICATION

Soils Though Time: From the Past to the Future II

Chairs:
F. Scarciglia *(Univ. Calabria)* / **F. Kurbanova** *(Inst. Geography RAS)*

14:30 - 14:45	**ORAL 10:**	**N. Mergelov.** *Inst. of Geography RAS, Moscow (Russia)*
	#635.	
	PROTO-SOILS OF EXTREME ENVIRONMENTS: A WINDOW INTO PRECAMBRIAN MODES OF SOIL FORMATION.	
14:45 - 15:00	**ORAL 11:**	**F. S. Bernardes-Ladeira *et al.*** *Unicamp, Campinas (Brazil)*
	#576.	
	COLLUVIUM-PEDOGENESIS RELATIONSHIP IN THE OPEN-AIR ARCHAEOLOGICAL SITE OF BASTOS (SÃO PAULO/ BRAZIL): 13,000 YEARS OF SLOPE EVOLUTION.	
15:00 - 15:15	**ORAL 12:**	**C. Huguet *et al.*** *Dpt. of Environ. Sci. for Sustainability, Segovia (Spain)*
	#479.	
	RECONSTRUCTING PALEOCLIMATOLOGY IN LATE HOLOCENE IN KONAR SANDAL, SE IRAN USING BIOMARKERS IN PEAT SOILS.	
15:15 - 15:30	**ORAL 13:**	**F. Kurbanova *et al.*** *Inst. of Geography RAS, Moscow (Russia)*
	#640.	
	PALEOSOL-SEDIMENT SEQUENCE AS ARCHIVE OF UPPER PALEOLITHIC ENVIRONMENTS OF THE KOSTENKI 17 SITE (VORONEZH REGION, RUSSIA).	
15:30 - 15:45	**ORAL 14:**	**C. Chenu *et al.*** *INRAE, Palaiseau (France)*
	#639.	
	EARLY PEDOGENESIS OF A YOUNG TECHNOSOL MADE FROM ORGANIC WASTES.	
15:45.16:00	**ORAL 15:**	**D. Sauer *et al.*** *Univ. of Goettingen (Germany)*
	#620.	
	TIMING AND CAUSE OF THE ONSET OF ENHANCED EROSION-SEDIMENTATION DYNAMICS IN MONGOLIA - CLIMATIC SHIFT OR HUMAN IMPACT? .	

16:00 - 16:30 — COFFEE + EXPO + POSTERS SESSION 1
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)



16:30 - 18:00	**SESSION: GT01. SOIL GENESIS, EVOLUTION & CLASSIFICATION**	
	Advances in Soil Mapping	
	Chairs: **A. Vacca** *(Univ. Cagliari)* / **S. Guerreiro** *(Univ. Lisboa)*	
16:30 - 16:45	**ORAL 16:**	**C. Kabala *et al.*** *Wroclaw Univ. of Environ. and Life Sci. (Poland)*
	#195.	
	DRIVERS OF THE SPATIAL DIVERSITY OF CHERNOZEMS AND ACCOMPANYING SOILS IN THE TARBAGATAI MOUNTAINS, SOUTH-EAST KAZAKHSTAN.	
16:45 - 17:00	**ORAL 17:**	**L. Boruvka *et al.*** *Czech Univ. of Life Sci., Prague (Czech Republic)*
	#861.	
	EFFECT OF ROCK FRAGMENTS ON SOIL ORGANIC CARBON STOCK ESTIMATION AND MAPPING IN FOREST SOILS OF THE CZECH REPUBLIC.	
17:00 - 17:15	**ORAL 18:**	**S Tanner *et al.*** *Bern Univ. of Appl. Sci. (BFH) (Switzerland)*
	#532.	
	PEDOLOGICAL TRANSECT SURVEYS TO ENHANCE DATA QUALITY FOR REGIONAL DIGITAL SOIL MAPPING.	
17:15 - 17:30	**ORAL 19:**	**M. Fuchs *et al.*** *Hungarian Univ. of Agric. and Life Sci., Gödöllo (Hungary)*
	#668.	
	PEDOMETRICS SUPPORTED EVALUATION OF CLASSIFICATION OF HYDROMORPHIC SOILS USING TRADITIONAL LABORATORY AND SPECTRAL SOIL DATA.	
17:30 - 17:45	**ORAL 20:**	**S. Mantel.** *ISRIC World Soil Information, Wageningen (The Netherlands)*
	#752.	
	THE ISRIC GLOBAL SOIL ARCHIVE: A VALUABLE RESOURCE.	
17:45 - 18:00	**ORAL 21:**	**E. Michéli *et al.*** *Hungarian Univ. of Agric. and Life Sci., Gödöllo (Hungary)*
	#837.	
	LESSONS FROM THE CORRELATION OF THE SOIL TYPES OF THE MODERNIZED, DIAGNOSTIC BASED HUNGARIAN SOIL CLASSIFICATION SYSTEM WITH THE REFERENCE SOILS GROUPS OF THE WRB.	

18:00 - 18:25	**FLASH ORAL SESSION**	**GT08 & GT12**
	Chairs: **P. Campos** *(IRNAS-CSIC)*	
18:00 - 18:05	**FLASH GT08-1:**	**Y Shi *et al.*** *Univ. Kiel (Germany) SENIOR*
	#90.	
	PEROXIDASE ACTIVITY OF FRESH APPLE ROOT: A NOVEL APPROACH OF RESORUFIN-BASED MICRO-ZYMOGRAPHY.	
18:05 - 18:10	**FLASH GT08-2:**	**Q. Chen *et al.*** *INRAE, Info&Sols, Orléans (France)*
	#345.	
	BARE SOIL MOSAICKING OPTIMISATION FOR SOIL ORGANIC CARBON PREDICTION IN CENTRE-VAL DE LOIRE (FRANCE).	
18:10 - 18:15	**FLASH GT08-3:**	**E. Z. Dobos *et al.*** *Univ. of Miskolc (Hungary)*
	#825.	
	SENSOR SET DEVELOPMENT FOR SMART IRRIGATION.	



18:15 - 18:20	**FLASH GT08-4:**	**S. Vingiani *et al.*** *Univ. of Naples Federico II, Portici (Italy)*
	#650.	
	SOIL-PLANT-WATER DYNAMICS IN VINEYARDS OF VOLCANIC AREAS IN SOUTHERN ITALY: A THREE-YEAR STUDY OF THE 'PIEDIROSSO' CULTIVAR IN THE CONTEXT OF CLIMATE CHANGE..	
18:20 - 18:25	**FLASH GT12-1:**	**M. A. Oke. Michael Adedotun** *Oke Found, Federal Capital (Nigeria)*
	#10.	
	THE FLOODING IN EIGHT (8) VILLAGES UNDER KWAITA BLOCK KWALI AREA COUNCIL OF THE FEDERAL CAPITAL TERRITORY ABUJA.	

TUESDAY 9th SEPTEMBER 2025

MEZQUITA Hall (Auditorium F, First floor)

09:45 - 11:00	**SESSION: GT08. SOIL, PLANT, WATER INTERACTIONS**	
	Chair: **C. J Dumat** *(INRAE)*	
09:45 - 10:00	**ORAL 01:**	**B. G. Dimattia *et al.*** *Univ. of Bologna (Italy)*
	#113.	
	ROOT TRAITS OF DIFFERENT WHEAT CULTIVARS INFLUENCE SOIL STRUCTURE AND HYDRAULIC PROPERTIES.	
10:00 - 10:15	**ORAL 02:**	**E. Wiedermann and A. Don.** *Thuenen Inst., Braunschweig (Germany)*
	#138.	
	ARTIFICIAL MACROPORES - A NEW APPROACH TO ENABLE PLANT ROOT ACCESS INTO SUBSOILS, IN THE PRESENCE OF SOIL COMPACTION.	
10:15 - 10:30	**ORAL 03:**	**R. Kodešová *et al.*** *Czech Univ. of Life Sci. Prague (Czech Republic)*
	#528.	
	UPTAKE AND ACCUMULATION OF MICROPOLLUTANTS CONTAINED IN IRRIGATION WATER OR BIOSOLIDS BY PLANTS.	
10:30 - 10 - 45	**ORAL 04:**	**M. Suska-Malawska *et al.*** *Univ. of Warsaw (Poland)*
	#24.	
	STUDYING THE INFLUENCE OF SOIL CHEMISTRY MOSAIC ON PLANT DIVERSITY IN THE UISU GLACIER FORELAND, EASTERN PAMIR: HAS TIME STOOD STILL?	
10:45 - 11:00	**ORAL 05:**	**F. Pearce *et al.*** *Lancaster Univ. (United Kingdom)*
	#847.	
	INFLUENCE OF GRASSLAND LEGUMES ON NUTRIENT CYCLING IN SEMI-ARID GRASSLAND SOILS, AND INTERACTIONS WITH NUTRIENT LIMITATION.	

11:00 - 12:00	**COFFEE + EXPO + POSTERS SESSION 1** **(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)**



12:00 - 13:00 — **SESSION: GT08. SOIL, PLANT, WATER INTERACTIONS**

Chair:
E. López-Capel *(Newcastle University)*

12:00 - 12:15 — **ORAL 06:** **T. J. Lopes *et al.*** *CIMO, LA SusTEC, Inst. Politécnico de Bragança (Portugal)*

#864.

MOISTURE MATTERS: SOIL CHEMISTRY AND MICROBIAL DYNAMICS IN COWPEA RHIZOSPHERES.

12:15 - 12:30 — **ORAL 07:** **A. J. Messiga *et al.*** *Agriculture and Agri-Food Canada, Agassiz (Canada)*

#655.

P CONCENTRATIONS IN SURFACE WATER SOURCES ADJACENT TO MAJOR CROPPING SYSTEMS ACROSS THE FRASER VALLEY, BRITISH COLUMBIA, CANADA.

12:30 - 12:45 — **ORAL 08:** **C. Hyeonji.** *Gyeongsang National Univ., Jinju (South Korea)*

#300.

PROTEOMIC AND PHYSIOLOGICAL RESPONSES OF RICE SEEDLINGS TO CHLORTETRACYCLINE STRESS.

12:45 - 13:00 — **ORAL 09:** **R. W. Simmons *et al.*** *Cranfield Univ., Bedford (United Kingdom)*

#213.

ANTI-CAPPING' POLYMERS SIGNIFICANTLY ENHANCE EMERGENCE, STAND ESTABLISHMENT AND YIELD IN BABY LEAF SPINACH.

13:00 - 14:30 — **LUNCH + EXPO + POSTERS SESSION 1**
IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

14:30 - 16:00 — **SESSION: GT08. SOIL, PLANT, WATER INTERACTIONS**

Chair:
E. Dambrine *(INRAE)*

14:30 - 14:45 — **ORAL 10:** **E. Pellegrini *et al.*** *Univ. of Udine (Italy)*

#452.

INFLUENCE OF INCREASED FRESHWATERS BROWNING ON IRON PLAQUE FORMATION IN HYDROPHYTES.

14:45 - 15:00 — **ORAL 11:** **Hui Rong *et al.*** *China Agricultural Univ., Beijing (China)*

#997.

THE IMPACT OF NO-TILLAGE ON ORGANIC CARBON IN DEEP ROOT-INDUCED SHEATH SOIL WITHIN NORTHEAST CHINA MOLLISOLS AND ANALYSIS OF STABILIZATION MECHANISMS.

15:00 - 15:15 — **ORAL 12:** **Á. Horel *et al.*** *ATK TAKI, Budapest (Hungary)*

#352.

SOIL CULTIVATION METHODS IN SLOPED VINEYARDS: BALANCING PLANT HEALTH, SOIL MOISTURE, AND GHG EMISSIONS.

15:15 - 15:30 — **ORAL 13:** **V. Tanaskovic-Gassner.** *Afforest for Future, Brzece (Serbia) & K. Koukaras. Certh, Thessaloniki (Greece)*

#20.

HARVESTING OF AGRICULTURAL NUTRIENT RUNOFF WITH ALGAE, TO PRODUCE NEW SOIL AMENDMENTS FOR URBAN AND PERI-URBAN OLIVE TREE AGROFORESTRY SYSTEMS IN SOUTHERN EUROPE.



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15:30 - 15:45 — **ORAL 14:** **P. Ganugi *et al.*** *Univ. of Turin (Italy)*

#629.

CONTRASTING ADAPTIVE ROOT SYSTEM STRATEGIES OF QUERCUS ROBUR AND Q. RUBRA TO SEVERE DROUGHT DRIVEN BY PHOSPHORUS SUPPLY.

15:45.16:00 — **ORAL 15:** **T. Törmänen *et al.*** *Natural Resources Inst. Finland, Helsinki (Finland)*

#496.

SOIL PROPERTIES ARE DRIVERS OF BROAD-SCALE FOREST VEGETATION VARIATION.

16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 1**
(IA - ground floor: GT9 & 11; IB- first floor: GT EUSO, 1, 2, 5, 8, 10 & 12)

16:30 - 18:00 — **SESSION: GT08.1. Linking Vegetation Indices and Soil Properties: Advances in Measurement, Monitoring, and Modelling**

Chairs:
A. Horel and Z. Bakacsi *(Institute for Soil Sci. Budapest)*

16:30 - 16:45 — **ORAL 16:** **M. Rolando *et al.*** *Univ. of Turin, Grugliasco (Italy)*

#737.

THE INTERPLAY BETWEEN DROUGHT AND PHOSPHORUS SCARCITY SHAPES RESILIENCE TO STRESS IN QUERCUS SPP. BY MODULATING METABOLOMIC PROFILES.

16:45 - 17:00 — **ORAL 17:** **H. Djuma *et al.*** *The Cyprus Institute, Nicosia (Cyprus)*

#329.

EFFECTS OF AFFORESTATION OF MARGINAL CROPLANDS ON SOIL PROPERTIES AND EVAPOTRANSPIRATION IN A SEMI-ARID ENVIRONMENT.

17:00 - 17:15 — **ORAL 18:** **M. López-Vicente *et al.*** *Univ. de Zaragoza, Huesca (Spain)*

#296.

SOIL COVERS, SOIL DEPTH AND CLIMATE MODULATE THE CORRELATION BETWEEN SOIL MOISTURE AND SOIL TEMPERATURE IN AN ORGANIC VINEYARD: OBSERVATIONS DURING THREE YEARS AT NEAR REAL-TIME.

17:15 - 17:30 — **ORAL 19:** **I. Vogeler *et al.*** *Christian Albrechts Univ., Kiel (Germany)*

#224.

SENSOR SYSTEM FOR REAL-TIME SOIL SOLUTION MONITORING IN AGRICULTURAL SYSTEMS.

17:30 - 17:45 — **ORAL 20:** **S. Sekhri *et al.*** *Univ. of Hamburg (Germany)*

#276.

OPTIMIZING COWPEA GROWTH IN SANDY SOILS: EFFECT OF MULCHING, INOCULATION, AND SIMULATED DROUGHT ON SOIL WATER DYNAMICS AND PLANT DEVELOPMENT.

17:45 - 18:00 — **ORAL 21:** **XXX**

M. Guiese *et al.* *Edmund Mach Foundation, Trento (Italy)*

#782.

IMPACT OF DOMESTICATION ON ROOT MICROBIOTA: A COMPARISON BETWEEN CULTIVATED AND WILD VARIETIES BIODIVERSITY.



18:00 - 18:20 FLASH ORAL SESSION GT07

Chairs:
C. Vitória *(Inst. Politécnico de Castelo Branco)*

18:00 - 18:05 **FLASH GT07-1:** **M. Pérez-Picón *et al.*** *Univ. de Sevilla (Spain)*
#599.
UNDERSTANDING THE KEYS BEHIND A SUCCESSFUL SUBSTITUTION OF P MINERAL FERTILIZATION.

18:05 - 18:10 **FLASH GT07-2:** **N. Núñez *et al.*** *Univ. de Sevilla (Spain)*
#348.
EVALUATION OF ORGANIC FERTILISERS AS AN ALTERNATIVE TO PHOSPHATE MINERAL FERTILISATION IN A WHEAT-SUNFLOWER ROTATION.

18:10 - 18:15 **FLASH GT07-3:** **M. Colomina-Garcia and Daniel Plaza-Bonilla.** *Univ. de Lleida (Spain)*
#356.
NITROGEN TRACING FROM COVER CROPS TO MAIZE: N FATE IN THE SOIL-PLANT SYSTEM.

18:15 - 18:20 **FLASH GT07-4:** **E. Loffredo *et al.*** *Univ. Aldo Moro, Bari (Italy)*
#355.
USE OF BIOSORBENTS FROM WASTE RECYCLING AND MYCODEGRADATION FOR THE EFFECTIVE AND LOW-COST ELIMINATION OF ORGANIC SOIL POLLUTANTS.

18:20 - 18:45 FLASH ORAL SESSION GT07

Chair:
S. Maletic *(Univ. Novi-Sad)*

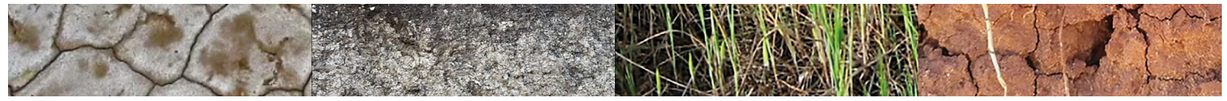
18:20 - 18:25 **FLASH GT07-5:** **J. Queiros-Vieira *et al.*** *Uni LaSalle, Beauvais (France)*
#413.
SHORT-TERM EFFECTS OF TORREFIED RAPESEED STRAW ON RYEGRASS GROWTH AND DISSOLVED SOIL ORGANIC CARBON.

18:25 - 18:30 **FLASH GT07-6:** **M. Sampériz Sarvisé and A. Usón Murillo.** *Univ. de Zaragoza, Huesca (Spain)*
#287.
LEACHED NITRATE QUANTIFICATION IN MAIZE: MICROPLOT, PLOT AND BASIN LEVEL.

18:30 - 18:35 **FLASH GT07-7** **D. Ruiz-Beamonte.** *CIRCE, Zaragoza (Spain)*
#225.
DEMONSTRATING THE AGRONOMIC POTENTIAL OF NITROGEN AND PHOSPHORUS RECOVERY FROM WASTE STREAMS IN THREE EUROPEAN RIVER BASINS (EBRO, LIELUPE, AND DANUBE).

18:35 - 18:40 **FLASH GT07-8:** **C. Esteves.** *Lisbon Univ. (Portugal) SENIOR*
#601.
SOIL ENZYME ACTIVITIES AND MICROBIAL COMMUNITIES AS INDICATORS OF SOIL HEALTH IN MANURE-AMENDED ORCHARD SOILS.

18:40 - 18:45 **FLASH GT07-09:** **O. I. Halima *et al.*** *INRA, Rabat (Morocco) SENIOR*
#862.
GREEN WASTE COMPOST AS AN ECO-FRIENDLY ALTERNATIVE TO REMEDIATE SALT-AFFECTED SOILS IN MOROCCO.



WEDNESDAY 10th SEPTEMBER 2025

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AL'ANDALUS Auditorium (Main Auditorium A, Ground floor)

09:00 - 09:45 PLENARY CONFERENCE

The Soils of Our Planet – A Fascinating Resource

Dr. Peter Schad *(Technical University of Munich, Germany)* **(Introduced by Dr. J. Mataix-Solera)**

09:45 - 11:00 SESSION: Status of Soils Worldwide: State of the Art and Future Prospects

Chair:
Natalia Rodríguez Eugenio *(FAO-GSP)*

09:45 - 09:55 OPENING

Thorunn Wolfram, *Secretary of the Global Soil Partnership (FAO)*

09:55 - 10:15 **KEYNOTE: Status of World's Soil Resources: current situation and major challenges**
Rosa Poch, *outgoing Chair of the Intergovernmental Technical Panel on Soils*

10:15 - 10:45 **INTERACTIVE PANEL:** **What do we know and what don't we know about the state of soils?**

Panos Panagos, *Joint Research Centre, European Commission (SWSR)*

Alex McBratney, *Univ. of Sydney (Australia)*

Aimé Jean Messiga, *Agriculture and AgriFood Canada, Agassiz (Canada)*

Bonginkosi Vilakazi, *North-West Univ. Mmabatho (South Africa)*

Shin-ichiro Mishima, *National Inst. for Agro-Environmental Sci., Tsukuba (Japan)*

Imene Dridi, *Univ. of Tunis El Manar, Tunis (Tunisia)*

10:45 - 10:55 **Open session for questions and answers**

10:55 - 11:00 **Conclusions and closure**

11:00 - 12:00 COFFEE + EXPO + POSTERS SESSION 2 (2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)



12:00 - 13:00 — **SESSION: GT09. SOIL HEALTH**

Biological and Biodiversity Indicators

Chair:
M. P. Antilén *(Pontificia Univ. Católica de Chile)*

12:00 - 12:15 — **ORAL 34:** **M. C. Hernandez-Soriano *et al.*** *John Innes Centre, Norwich (United Kingdom)*
#402.
WHEAT ROOT TRAITS CAN TURN THE TIDE OF THE NITROGEN CYCLE IN SOIL.

12:15 - 12:30 — **ORAL 35:** **A. Roy *et al.*** *ZALF, Müncheberg (Germany)*
#264.
AUTOMATING BAIT LAMINA STICK EVALUATION WITH COMPUTER VISION: A SCALABLE AND OBJECTIVE APPROACH FOR SOIL MESOFAUNA ACTIVITY ASSESSMENT.

12:30 - 12:45 — **ORAL 36:** **L. B. Martínez-García *et al.*** *EEAD-CSIC, Zaragoza (Spain)*
#426.
INTERCROPPING AND BIOPESTICIDE USE IMPACT SOIL MICROBIAL, MYCORRHIZAL RESPONSES AND PLANT DAMAGE IN ORGANIC MAIZE–COTTON SYSTEMS IN WEST AFRICA.

12:45 - 13:00 — **ORAL 37:** **N. Flórián *et al.*** *HUN-REN, Budapest (Hungary)*
#363.
SOIL MESOFAUNA AS SOIL HEALTH INDICATOR: LESSONS FROM CONSERVATION AGRICULTURAL AND FORESTRY SYSTEMS.

13:00 - 14:30 — **LUNCH + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 16:00 — **SESSION: GT09. SOIL HEALTH**

Chair:
M. Demeulemeester *(INAGRO)*

14:30 - 14:45 — **ORAL 38:** **L. Federico *et al.*** *Univ. Milano-Bicocca (Italy)*
#551.
SOIL UNDER PRESSURE: WHAT TERRESTRIAL ISOPOD AGGREGATION PATTERNS REVEAL ABOUT ECOSYSTEM HEALTH.

14:45 - 15:00 — **ORAL 39:** **J. M. Mirás-Avalos *et al.*** *MBG-CSIC, Santiago de Compostela (Spain)*
#62.
SOIL MICROBIAL BIOMASS AND ORGANIC CARBON IN AGRICULTURAL FIELDS OF THE EBRO VALLEY (NE SPAIN) UNDER DIFFERENT MANAGEMENT PRACTICES.

15:00 - 15:15 — **ORAL 40:** **C. Vázquez *et al.*** *Wageningen Univ. (The Netherlands)*
#622.
SOIL BIOLOGY, SOIL HEALTH AND ECOSYSTEM SERVICES.

15:15 - 15:30 — **ORAL 41:** **L. Corbett,** *Univ. Reading (United Kingdom)*
#603.
SOIL ENZYME ACTIVITY RATES AS SENSITIVE INDICATORS OF SOIL HEALTH FOR OAK DECLINE IN RESPONSE TO DROUGHT, REWETTING AND NUTRIENT STRESS.



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15:30 - 15:45 — **ORAL 42:** **P. R. Soares *et al.*** *Wageningen Univ. & Res. (The Netherlands)*
#404.
ASSESSING SOIL HEALTH AND MAIZE PERFORMANCE IN SUCCESSIONAL AGROFORESTRY SYSTEMS ACROSS TWO MEDITERRANEAN FARMS.

15:45.16:00 — **ORAL 43:** **M. Zhiyanski *et al.*** *Forest Res. Inst.-BAS, Sofia (Bulgaria)*
#76.
SOIL BIO-MONITORING IN POLAR ECOSYSTEMS: FINDINGS FROM LIVINGSTON ISLAND, ANTARCTICA.

16:00 - 16:30 — **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

16:30 - 18:00 — **SESSION: GT09. SOIL HEALTH**

Conceptual Frameworks & Assessment II

Chair:
E. Álvarez-Rodriguez *(Uni. Santiago de Compostela)*

16:30 - 16:45 — **ORAL 44:** **A. Brauman *et al.*** *IRD, Montpelier (France)*
#199.
FROM FERTILITY TO FUNCTION: THE EVOLVING NARRATIVES OF SOIL HEALTH AND QUALITY.

16:45 - 17:00 — **ORAL 45:** **N. Schmücker *et al.*** *BFH, Bern (Switzerland)*
#439.
OF AGGREGATES AND PORES: A MULTI-METHOD FRAMEWORK TO ASSESS SOIL STRUCTURE AND FUNCTION ACROSS LAND-USE AND TEXTURE GRADIENTS.

17:00 - 17:15 — **ORAL 46:** **C. Morgan *et al.*** *Soil Health Inst., Morrisville (USA)*
#808.
WHAT COUNTS AS ADOPTION? BETTER ACCOUNTING OF SOIL HEALTH MANAGEMENT PRACTICES.

17:15 - 17:30 — **ORAL 47:** **M. D. Kessie *et al.*** *UniLaSalle, Beauvais (France)*
#301.
SOIL ECOSYSTEM SERVICES: LINKING CONCEPTS, ASSESSMENT METHODS, RELATIONSHIPS, AND POLICY-MAKING.

17:30 - 17:45 — **ORAL 48:** **M. Wallenstein *et al.*** *Syngenta, Basel (Switzerland)*
#454.
MOVING PAST METRICS: A DATA-DRIVEN STRATEGY FOR RESTORING SOIL HEALTH AT SCALE.

17:45 - 18:00 — **ORAL 49:** **S. Crittenden *et al.*** *Agric. and Agri-Food Canada, Brandon (Canada)*
#140.
SOIL HEALTH INDICATORS FOR CROPPING SYSTEMS IN MANITOBA, CANADA.

20:30 - LATE — **GALA DINNER**



WEDNESDAY 10th SEPTEMBER 2025

ITALICA Auditorium (Auditorium B, First floor)

09:00 - 09:45 — PLENARY CONFERENCE

Biochar a Magic Soil Amendment or How Does it Affect Soil Biochemistry?

by Dr. Heike E. Knicker *(Instituto de la Grasa (IG-CSIC), Spain)* **(Presented by Dr. J. Mª de la Rosa)**

09:45 - 11:00 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

Mineral Fertilization I

Chair:
H. Knicker *(IG-CSIC)*

09:45 - 10:00 — **ORAL 19:** **K. Nikolaus *et al.*** *Wageningen Environ. Res. (The Netherlands)*
#764.
REGIONAL SPECIFIC MEASURES TO REDUCE TRADE-OFFS AND PROMOTE SYNERGIES BETWEEN CLIMATE CHANGE MITIGATION AND SOIL HEALTH.

10:00 - 10:15 — **ORAL 20:** **N. Dube.** *Univ. of KwaZulu-Natal, Dubban (South Africa)*
#29.
LONG-TERM (71 YEARS) NITROGEN AND LIME APPLICATION IMPACTS MICROBIAL RESILIENCE, STOICHIOMETRIC CONSTRAINTS, AND SOIL CARBON STABILITY IN A SEMI-ARID GRASSLAND.

10:15 - 10:30 — **ORAL 21:** **A. Simoes-Mota *et al.*** *EEAD-CSIC, Zaragoza (Spain)*
#178.
BALANCING FERTILITY AND CONTAMINATION IN THE MEDITERRANEAN: TRACE ELEMENTS AND NUTRIENT DYNAMICS UNDER 12 YEARS OF CONTRASTING SOIL MANAGEMENT.

10:30 - 10:45 — **ORAL 22:** **I. M. Becerra-Vela *et al.*** *Univ. of Seville (Spain)*
#219.
UNLOCKING MICRONUTRIENT POTENTIAL: IRON (FE) AND ZINC (ZN) BIOFORTIFICATION VIA BIOBASED FERTILIZER STRATEGIES.

10:45 - 11:00 — **ORAL 23:** **C. Dayan *et al.*** *Hebrew Univ. in Jerusalem, Rehovot (Israel)*
#197.
POLYSACCHARIDE-COATED APATITE FORMULATIONS: A SYNERGISTIC STRATEGY FOR PHOSPHORUS AVAILABILITY AND REDUCED ENVIRONMENTAL MIGRATION.

11:00 - 12:00 — COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)



12:00 - 13:00 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

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Mineral Fertilization II

Chairs:
A. J. Messiga *(Agric. & Agri-Food Canada)* **/ K. Nikolaus** *(Wageningen Environ. Res.)*

12:00 - 12:15 — **ORAL 24:** **K. Hayashi. Res.** *Institute for Humanity and Nature, Kyoto (Japan)*
#149.
ROLE OF SOIL SCIENCE IN SUSTAINABLE NITROGEN MANAGEMENT.

12:15 - 12:30 — **ORAL 25:** **A. A. Rahman *et al.*** *SD Guthrie Research Sdn Bhd, Pulau Carey (Malaysia)*
#569.
USE OF OIL PALM DECANTER CAKE AS SOIL AMENDMENT AND INORGANIC FERTILISER SUBSTITUTE FOR GROWING OIL PALM SEEDLINGS IN THE NURSERY.

12:30 - 12:45 — **ORAL 26:** **L. Guerrero-Gallardo *et al.*** *Univ. of Córdoba (Spain)*
#521.
COMPOSTED SEWAGE SLUDGE AS PHOSPHORUS FERTILIZER IN WHEAT GROWN IN REPRESENTATIVE SOILS OF SPAIN.

12:45 - 13:00 — **ORAL 27:** **A. González-Guzmán and D. Arán-Ferreiro.** *Univ. de Córdoba (Spain)*
#208.
DESIGN AND PERFORMANCE OF AN INOCULATED WASTE-BASED ORGANIC MINERAL FERTILIZER FOR GRAPEVINES.

13:00 - 14:30 — LUNCH + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 16:00 — SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS

Chars as Soil Amendments & Impact on the Soil-Plant-Microorganism System

Chair:
H. Knicker *(IG-CSIC)* **/ F. Moreno-Racero** *(IG-CSIC)*

14:30 - 14:45 — **ORAL 28:** **J. L. Thauront *et al.*** *École Normale Supérieure-PSL, CNRS, IPSL, Paris (France)*
#297.
PYROLYSIS TEMPERATURE IS NOT A GOOD PROXY OF BIOCHAR PERSISTENCE IN SOILS.

14:45 - 15:00 — **ORAL 29:** **S. Schlichenmaier *et al.*** *Research Institute of Organic Agriculture, Frick (Switzerland)*
#290.
EFFECTS OF BIOCHAR APPLICATION ON SOIL QUALITY AND CROP YIELDS: RESULTS FROM THE INITIAL FOUR YEARS OF A LONG-TERM FIELD EXPERIMENT IN SWITZERLAND.

15:00 - 15:15 — **ORAL 30:** **J. M. de la Rosa *et al.*** *IRNAS-CSIC, Seville (Spain)*
#411.
ORGANIC AMENDMENTS FROM RESIDUES FOR SOIL HEALTH, LONG TERM CARBON STABILITY AND NUTRIENT RECYCLING.

15:15 - 15:30 — **ORAL 31:** **P. Tammeorg *et al.*** *Univ. Helsinki (Finland)*
#710.
TOWARDS THE BEST PRACTICE IN USING SOFTWOOD BIOCHARS ON BOREAL SOILS: RESULTS FROM TWO EXPERIMENTS THROUGH 15 YEARS ON SOILS, NUTRIENT CYCLING AND CROPS.



15:30 - 15:45	**ORAL 32:**	**C. Vitória *et al.*** *Inst. Politécnico de Castelo Branco (Portugal)*
	#78.	
	AGRONOMIC ASSESSMENT OF BIOCHAR VALORIZATION IN AN ACIDIC AND LOW PHOPHORUS SOIL.	
15:45.16:00	**ORAL 33:**	**F. J. Moreno-Racero *et al.*** *IG-CSIC, Seville (Spain)*
	#252.	
	FROM TAXA TO FUNCTION: PREDICTING METABOLIC PATHWAYS OF AGRONOMIC AND ENVIRONMENTAL RELEVANCE IN HYDROCHAR-AMENDED SOILS.	

16:00 - 16:30 **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

16:30 - 18:00 **SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS**

Chair:
Ana Barreiro *(Univ. Santiago de Compostela)*

16:30 - 16:45	**ORAL 34:**	**L. Lesaint *et al.*** *UniLa Salle, Beauvais (France)*
	#294.	
	ASSESSMENT OF THE IMPACT OF TORREFIED RAPESEED STRAW APPLICATION ON SOIL MULTIFUNCTIONALITY USING THE BIOFUNCTOOL APPROACH.	
16:45 - 17:00	**ORAL 35:**	**H. Luutu *et al.*** *Univ. Adelaide (Australia)*
	#677.	
	VISUALISING THE AMELIORATION OF SUBSURFACE SOIL ACIDITY WITH X-RAY TOMOGRAPHY: THE EFFECT OF NOVEL MICRONISED LIME WITH POLYMERS	
17:00 - 17:15	**ORAL 36:**	**M. Caldara *et al.*** *UNIPR, Parma (Italy)*
	#767.	
	A CONTRIBUTION TO MISSION SOIL FROM TWO HORIZON PROJECTS: SIMBA AND DELISOIL.	
17:15 - 17:30	**ORAL 37:**	**M. Knott *et al.*** *RPTU, Landau In Der Pfalz (Germany)*
	#441.	
	FROM ASHES TO OAKS: HOW LONG-TERM EFFECTS OF BIOCHAR ON BIOPHYSICOCHEMICAL SOIL PROPERTIES MAY AFFECT SURVIVAL AND GROWTH OF QUERCUS PETRAEA IN A FOREST RESTORATION PROJECT.	
17:30 - 17:45	**ORAL 38:**	**K. Barcauskaite *et al.*** *Lithuanian Res. Centre for Agr. and Forestry, Kaunas, (Lithuania)*
	#511.	
	MICROPLASTICS FROM ORGANIC MATTER-RICH SEWAGE SLUDGE: THEIR ROLE IN HEAVY METAL TRANSPORT.	
17:45 - 18:00	**ORAL 39:**	**S. Bhattarai *et al.*** *Stiftung Univ., Hildesheim (Germany)*
	#477.	
	SOIL ORGANIC MATTER QUALITY INFLUENCES EARTHWORM ABUNDANCE IN WOOD PASTURES OF ROMANIA: HIGHER RECALCITRANCE AND LOWER ABUNDANCE UNDER TREE CROWNS.	

20:30 - LATE **GALA DINNER**



WEDNESDAY 10th SEPTEMBER 2025

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RONDA Hall (Auditorium C, First floor)

09:45 - 11:00 **SESSION: GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING**

Integrating Ground Observations and Satellites for Carbon Sensing of Soil and Vegetation I (Remote Sensing)

Chairs:
E. Vaudour *(INRAE Versailles-Saclay)* **/ Y. Fouad** *(Inst. Agro Rennes-Angers)*

09:45 - 10:00	**ORAL 01:**	**Q. Chen *et al.*** *INRAE, Info&Sols, Orléans (France)*
	#255.	
	SPECTRAL INDICES IN REMOTE SENSING OF SOIL: DEFINITION, POPULARITY, AND ISSUES. A CRITICAL OVERVIEW.	
10:00 - 10:15	**ORAL 02:**	**M. A. Abubakar *et al.*** *AgroParisTech-INRAE, Palaiseau (France)*
	#293.	
	SPATIAL PREDICTION OF SOIL PROPERTIES USING SENTINEL-2 TEMPORAL MOSAICS OF NON-VEGETATED SOILS IN A SEMI-ARID REGION: A COMPARATIVE EVALUATION OF GOOGLE EARTH ENGINE AND THEIA PLATFORMS IN SMINJA PLAIN, TUNISIA.	
10:15 - 10:30	**ORAL 03:**	**H. Zayani *et al.*** *Univ. Paris-Saclay, Palaiseau (France)*
	#139.	
	DETECTION OF SOIL MANAGEMENT PRACTICES USING SENTINEL-1 TIME SERIES: THE CHALLENGES RAISED BY THE DIVERSIFIED MANAGEMENT SEQUENCES IN VINEYARDS.	
10:30 - 10:45	**ORAL 04:**	**X. Tian *et al.*** *OpenGeoHub, Doorwerth (The Netherlands)*
	#39.	
	SPATIOTEMPORAL PREDICTION OF SOIL ORGANIC CARBON DENSITY FOR EUROPE (2000--2022) BASED ON LANDSAT-BASED SPECTRAL INDICES TIME-SERIES.	
10:45 - 11:00	**ORAL 05:**	**A. Paz *et al.*** *Univ. Lisbon (Portugal)*
	#312.	
	REGIONAL MAPPING OF SOIL ORGANIC CARBON IN AGRICULTURAL SOILS FROM SENTINEL-2 IMAGERY.	

11:00 - 12:00 **COFFEE + EXPO+ POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 **SESSION: GT10. SOIL C DYNAMICS & STABILIZATION**

Amended Soils

Chair:
P. Madejón *(IRNAS-CSIC)*

12:00 - 12:15	**ORAL 45:**	**P. De Jong *et al.*** *WSL, Birmensdorf (Switzerland)*
	#464.	
	THE ROLE OF EARTHWORMS IN ORGANIC MATTER CYCLING IN TEMPERATE FORESTS – A MESOCOSM EXPERIMENT WITH LABELLED BEECH LITTER.	



12:15 - 12:30	**ORAL 40:**	**M. Fér *et al.*** *Czech Univ. of Life Sci. (Czech Republic)*
	#516.	
	HOW TREATED WASTEWATER AND BIOSOLIDS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT AFFECT CARBON DIOXIDE EFFLUXES FROM SOILS.	
12:30 - 12:45	**ORAL 41:**	**P. Solé *et al.*** *IRTA - Mas Badia, La Tallada D'Empordà (Spain)*
	#665.	
	THE USE OF DIFFERENT TYPES OF MANURE AFFECTS SOIL PARTICULATE ORGANIC MATTER FRACTIONS.	
12:45 - 13:00	**ORAL 42:**	**L. Lozano De Sosa *et al.*** *IRNAS-CSIC, Seville (Spain)*
	#424.	
	UNPACKING THE ROLE OF LIVESTOCK DIVERSITY IN SOIL PROCESSES AND CARBON DYNAMICS	

13:00 - 14:30 LUNCH + EXPO+ POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 16:00 SESSION: GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

Integrating Ground Observations and Satellites for Carbon Sensing of Soil and Vegetation II (Proximal Sensing)

Chair:
N. Baghdadi *(INRAE Montpelllier)*

14:30 - 14:45	**ORAL 07:**	**Y.-C. Huang *et al.*** *Univ. of Sydney (Australia)*
	#162.	
	EVALUATING THE UNCERTAINTY OF DEEP LEARNING SOIL SPECTRAL MODELS USING MONTE CARLO CONFORMAL PREDICTION (MC-CP).	
14:45 - 15:00	**ORAL 08:**	**D. Gabrieli *et al.*** *Univ. di Padova (Italy)*
	#486.	
	INTEGRATING AUTONOMOUS PLATFORMS AND MULTI-GEOPHYSICAL SURVEYS FOR FIELD-SCALE SOIL COMPACTION DIAGNOSIS.	
15:00 - 15:15	**ORAL 09:**	**M. Naeimi *et al.*** *Univ. of Guelph (Canada)*
	#170.	
	ENVIRONMENTAL FACTORS IN IMAGE-BASED SOIL ANALYSIS: INTERACTION EFFECTS OF MOISTURE, TEXTURE, AND ILLUMINATION.	
15:15 - 15:30	**ORAL 10:**	**Y. Fouad *et al.*** *SAS, Institut Agro, INRAE, Rennes (France)*
	#751.	
	ESTIMATING VAN GENUCHTEN MODEL PARAMETERS FROM NEAR-INFRARED SPECTROSCOPY AND THE SOIL WATER SPECTRAL INDEX.	
15:30 - 15:45	**ORAL 11:**	**H. Merlet *et al.*** *Univ. Paris-Saclay, Palaiseau (France)*
	#367.	
	IMPROVING THE PREDICTION OF SOIL ORGANIC CARBON CONTENT USING FIELD-ACQUIRED HYPERSPECTRAL DATA BY ACCOUNTING FOR SOIL MOISTURE AND SURFACE ROUGHNESS.	
15:45 - 16:00	**ORAL 12:**	**A. Csorba *et al.*** *Hungarian Univ. of Agric. and Life Sci., Godollo (Hungary)*
	#833.	
	NATIONAL SOIL SPECTRAL LIBRARY FOR HUNGARY: ESTABLISHMENT AND PROSPECTS FOR SPECTROSCOPY-BASED SOIL ASSESSMENT, CLASSIFICATION AND MONITORING.	



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16:00 - 16:30 COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

16:30 - 18:00 SESSION: GT10. SOIL C DYNAMICS & STABILIZATION

Forest Soils

Chair:
A. Cervera-Mata *(CEBAS-CSIC)*

16:30 - 16:45	**ORAL 44:**	**F. Palmeira-Gabetto *et al.*** *LNBR/CNPEM, Campinas (Brazil)*
	#577.	
	EXPLORING THE RELATIONSHIP BETWEEN BIOCHAR FUNCTIONAL GROUPS AND SOIL CARBON MINERALIZATION DYNAMICS AND PRIMING EFFECT.	
16:45 - 17:00	**ORAL 45:**	**K. Staszel-Szlachta.** *Univ. of Agriculture in Krakow (Poland)*
	#90.	
	THE INFLUENCE OF DIFFERENT EUROPEAN TREE SPECIES ON THE STABILIZATION OF SOIL ORGANIC MATTER.	
17:00 - 17:15	**ORAL 46:**	**C.-F. Johannesson *et al.*** *NINA, Oslo (Norway)*
	#248.	
	DECADAL DECLINE IN FOREST FLOOR SOIL ORGANIC CARBON AFTER CLEAR-CUTTING IN NORDIC AND CANADIAN FORESTS.	
17:15 - 17:30	**ORAL 47:**	**E. Vanguelova *et al.*** *Forest Research, Farnham (United Kingdom)*
	#633.	
	WHAT IS THE CURRENT CARBON STORAGE AND FUTURE CARBON SEQUESTRATION POTENTIAL OF FOREST SOILS IN THE UK?	
17:30- 17:45	**ORAL 48:**	**P. Horvat *et al.*** *Slovenian Forestry Inst., Ljubljana (Slovenia)*
	#834.	
	SOIL CARBON STOCKS AND STABILITY UNDER EUROPEAN BEECH AND NORWAY SPRUCE STANDS IN DEPENDENCE ON PARENT MATERIAL.	
17:45- 18:00	**ORAL 49:**	**K. Ilmari** *and* **E. Vanguelova.** *Forest Res., Edinburgh & Farnham (United Kingdom)*
	#701.	
	CARBON SEQUESTRATION AND AMMONIA ABATEMENT IN POULTRY AGROFORESTRY SYSTEMS.	

18:00 - 19:00 ECSSS GENERAL ASSEMBLY

20:30 - LATE GALA DINNER



WEDNESDAY 10th SEPTEMBER 2025

BAHIA Hall (Auditorium D, First floor)

09:45 - 11:00 — SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY

Effects of Land Management on Soil Biota I

Chair:
E. Kandeler *(Univ. Hohenheim)*

09:45 - 10:00 — **ORAL 1:** **M. M. López-Rodríguez *et al.*** *Univ. of Granada. (Spain)*

#289.

SOIL MICROBIAL COMMUNITIES AS DRIVERS OF HEALTH AND RESILIENCE IN MEDITERRANEAN DRYLAND AGRICULTURE.

10:00 - 10:15 — **ORAL 2:** **L. Gismero-Rodríguez *et al.*** *IG-CSIC, Sevilla (Spain)*

#303.

A ONE-YEAR CHRONOSEQUENCE ANALYSIS OF MICROBIAL COMMUNITIES IN AN OLIVE ORCHARD UNDER VARYING MANAGEMENT PRACTICES.

10:15 - 10:30 — **ORAL 3:** **T. Jeanne *et al.*** *Univ. Laval Res. Center, Québec (Canada)*

#361.

AN INTEGRATED SOIL OMICS AND MACHINE LEARNING APPROACH TO PREDICT MULTIFUNCTIONALITY IN AGRICULTURAL SYSTEMS.

10:30 - 10:45 — **ORAL 4:** **C. Joly *et al.*** *Univ d'Avignon (France)*

#325.

DUNG BEETLES DOESN'T PLAY DIRTY.

10:45 - 11:00 — **ORAL 5:** **O. I. Halima *et al.*** *Hassan II Inst. for Agron. and Vet. Med. Rabat, (Morocco)*

#779.

SOIL MICROBIAL BIOMASS UNDER NO-TILL PRACTICE AND CONVENTIONAL TILLAGE IN A VERTISOL OF CENTRAL MOROCCO.

11:00 - 12:00 — COFFEE + EXPO+ POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 — SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY

Effects of Land Management on Soil Biota II

Chairs:
E. Morillo *(IRNAS-CSIC)* / **N. Praeg** *(Universität Innsbruck)*

12:00 - 12:15 — **ORAL 6:** **B. Betancur-Corredor *et al.*** *Univ. of Bonn (Germany)*

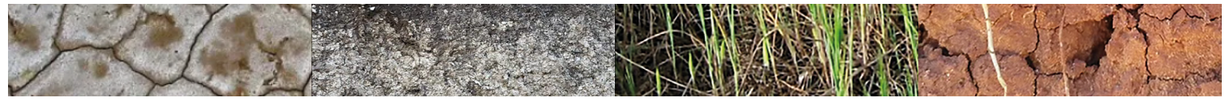
#399.

AGRICULTURAL LAND USE REDUCES SOIL BIODIVERSITY: INSIGHTS FROM A GLOBAL META-ANALYSIS.

12:15 - 12:30 — **ORAL 7:** **C. Menta *et al.*** *Univ. of Parma (Italy)*

#427.

AN INTEGRATED APPROACH TO DEFINE THE SOIL ARTHROPOD COMMUNITY RESPONSE IN AGRIVOLTAIC SYSTEMS.



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12:30 - 12:45 — **ORAL 8:** **R. Creamer.** *Wageningen Univ. and Res. (The Netherlands)*

#698.

HOW USEFUL ARE SOIL BIOTA AS INDICATORS OF SOIL HEALTH: UNDERSTANDING THE IMPACTS OF MANAGEMENT PRACTICES ON SOIL BIOTA AND ASSOCIATED SOIL FUNCTIONS.

12:45 - 13:00 — **ORAL 9:** **F. David *et al.*** *Wageningen Univ. and Res. (The Netherlands)*

#750.

IMPACT OF SOIL BIODIVERSITY LOSS AND SOIL COMMUNITY COMPOSITION ON SOIL STRUCTURAL PROCESSES AND ECOSYSTEM MULTIFUNCTIONALITY.

13:00 - 14:30 — LUNCH + EXPO+ POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 16:00 — SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY

Effects of Land Management on Soil Biota III

Chairs:
G. Bárcenas *(Univ. Sevilla)*
B. Betancur *Corredor (Univ. Bonn)*

14:30 - 14:45 — **ORAL 10:** **E. L. Rieke *et al.*** *Soil Health Institute, Morrisville (USA)*

#788.

MOVING BEYOND LAND USE CHANGE: HOW SPECIFIC AGRICULTURAL MANAGEMENT PRACTICES IMPACT SOIL MICROBIAL TAXONOMY AND CARBON CYCLING TRAITS.

14:45 - 15:00 — **ORAL 11:** **R. Barros *et al.*** *Univ. of Burgos (Spain)*

#807.

DROUGHT-DRIVEN SHIFTS IN WHEAT-ASSOCIATED MICROBIOMES: INSIGHTS FROM SPAIN AND ITALY.

15:00 - 15:15 — **ORAL 12:** **D. Szlatenyi *et al.*** *Eötvös Lóránd Univ., Budapest (Hungary)*

#812.

LAND-USE GRADIENT EFFECTS ON SOIL MICROBES: ARBUSCULAR MYCORRHIZAL FUNGI SHOW DISTINCT SENSITIVITY FROM NATURAL TO MANAGED SOILS.

15:15 - 15:30 — **ORAL 13:** **E. Baraza *et al.*** *Univ. of the Balearic Islands, Palma (Spain)*

#237.

HERBIVORY EFFECT ON SOIL FUNGI COMMUNITY: FROM ROOTS TO PLANT COMPETITION.

15:30 - 15:45 — **ORAL 14:** **M. Duarte *et al.*** *Politech. Inst. Santarém (Portugal)*

#179.

INFLUENCE OF COVER CROPS ON SOIL MESOFAUNA IN AGRICULTURAL SYSTEMS IN PORTUGAL.

15:45 - 16:00 — **ORAL 15:** **M. Liu.** *China Agric. Univ., Beijing (China)*

#964.

EFFECT OF COMPACTION ON THE NUMBER AND MORPHOLOGY OF GROUND-NESTING BEE BURROWS.



16:00 - 16:30 — **COFFEE + EXPO+ POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

16:30 - 18:00 — **SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY**

Dynamics and Drivers

Chairs:
M. Muñoz-Rojas *(IRNAS-CSIC)* / **A. Giraldo Silva** *(Univ. Pública de Navarra)*

16:30 - 16:45 — **ORAL 16:** **E. Kandeler *et al.*** *Univ. of Hohenheim, Stuttgart (Germany)*
#99.
SOIL MICROHABITATS – HOW DO SOIL MICROORGANISMS BENEFIT FROM THEIR LOCAL ENVIRONMENT?

16:45 - 17:00 — **ORAL 17:** **M. Du *et al.*** *Univ. of Sydney, Sydney (Australia)*
#131.
DIVERGENT ASSEMBLY: UNRAVELLING SOIL MICROBIAL DYNAMICS ACROSS CLIMATE AND LAND-USE GRADIENTS.

17:00 - 17:15 — **ORAL 18:** **R. Olmo-Gilabert *et al.*** *CREAF, Cerdanyola del Vallès, Barcelona (Spain)*
#328.
EXPLORING SOIL BIODIVERSITY PATTERNS THROUGH A MULTI-TAXA AND MULTI-ENVIRONMENTAL LENS.

17:15 - 17:30 — **ORAL 19:** **J. J. Jiménez *et al.*** *IPE-CSIC, Jaca (Spain)*
#492.
SOIL BIOTA COMMUNITIES AND KEY SOIL ECOSYSTEM FUNCTIONING PROCESSES ACROSS A MEDITERRANEAN CLIMATIC GRADIENT.

17:30 - 17:45 — **ORAL 20:** **N. Praeg *et al.*** *Univ. Innsbruck, Innsbruck (Austria)*
#538.
CROSS-HABITAT MICROBIAL INTERCONNECTEDNESS IN ALPINE GRASSLAND ECOSYSTEMS.

17:45 - 18:00 — **ORAL 21:** **N. Elnaker *et al.*** *TU Delft, (The Netherlands)*
#648.
SOIL FORMATION FROM DREDGED SEDIMENT: EVOLUTION OF BIOCHEMICAL AND PHYSICAL PROPERTIES.

20:30 - LATE — **GALA DINNER**



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MARISMAS Hall (Auditorium E, First floor)

09:45 - 11:00 — **SESSION: GT03. SOIL BIOGEOCHEMISTRY**

Changing Environment and Land-Use

Chair:
I. Schöning *(Max Planck Inst. for Biogeochem, Jena)*

09:45 - 10:00 — **ORAL 01:** **D. Kupka *et al.*** *Univ. of Agric. in Krakow (Poland)*
#56.
TOO HOT TO HANDLE: WARMING-INDUCED CHANGES IN BIOGEOCHEMISTRY OF TOPSOIL AND MAIN FOREST FORMING SPECIES IN TEMPERATE MOUNTAIN FORESTS IN CENTRAL EUROPE.

10:00 - 10:15 — **ORAL 02:** **N. Pacay-Barrientos *et al.*** *Tech. Univ. of Munich, Freising (Germany)*
#658.
SOIL ORGANIC MATTER STORAGE AND COMPOSITION AS MEDIATED BY LAND USE INTENSITY AND PEDOGENIC AND CLIMATIC FACTORS IN TEMPERATE GRASSLANDS.

10:15 - 10:30 — **ORAL 03:** **C. Kenny *et al.*** *Univ. of Stirling (United Kingdom)*
#494.
THE KEEL OF THE ICEBERG: ELUCIDATING THE IMPACTS OF SCOTTISH WOODLAND EXPANSION ON SOIL ORGANIC CARBON STORAGE IN PODZOLIC MINERAL HORIZONS.

10:30 - 10:45 — **ORAL 04:** **M. T. Domínguez *et al.*** *Univ. de Sevilla (Spain)*
#609.
POTENTIAL BENEFITS OF CONSERVATION TILLAGE ON THE STABILITY OF SOIL FERTILITY, BIODIVERSITY AND CROP PRODUCTIVITY AGAINST RAINFALL REDUCTION IN MEDITERRANEAN AGROECOSYTEMS.

10:45 - 11:00 — **ORAL 05:**
To be confirmed.

11:00 - 12:00 — **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 — **SESSION: GT03. SOIL BIOGEOCHEMISTRY**

Chairs:
T. Z. Lerch *(IEES-Paris)*
A. Delgado *(University of Seville)*

12:00 - 12:15 — **ORAL 06:** **I. Ollio *et al.*** *Univ. Politécnica de Cartagena (Spain)*
#96.
PLANT GROWTH-PROMOTING MICROORGANISMS CAN REDUCE CO2 EMISSIONS AND ENHANCE POTATO QUALITY UNDER MEDITERRANEAN CONDITIONS.

12:15 - 12:30 — **ORAL 07:** **J. N. Cantero *et al.*** *Univ. de Sevilla (Spain)*
#542.
OVERCOMING THE LIMITATIONS AT DETERMINING MICROBIAL P IN SOIL: ALTERNATIVES TO THE CLASSIC FUMIGATION-EXTRACTION PROCEDURE.



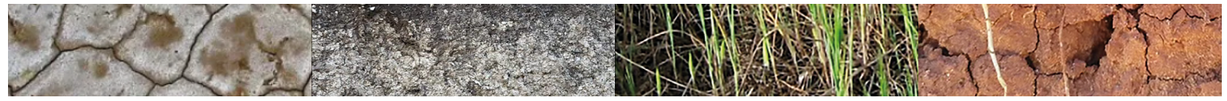
12:30 - 12:45	**ORAL 08:**	**V. Almeida *et al.*** *Univ. of Trás-os-Montes and Alto Douro, Vila Real (Portugal)*
	#568.	
	MODELING THE EFFECT OF LIMING ON THE FUNCTIONING OF A WINEGROWING VERY ACIDIC SOIL.	
12:45 - 13:00	**ORAL 09:**	**I. Schöning and M. Schrumpf.** *Max Planck Inst. for Biogeochem., Jena (Germany)*
	#581.	
	MICROBIAL BIOMASS OF CO2 FIXING MICROORGANISMS IS STABILIZED IN LIGHT AS WELL AS MINERAL ASSOCIATED SOIL ORGANIC MATTER FRACTIONS OF FOREST SOILS.	
12:45 - 13:00	**ORAL09:**	**T. Danise *et al.*** *Univ. of Campania "Luigi Vanvitelli", Caserta (Italy)*
	#214.	
	SOIL AND ENZYME STOICHIOMETRY IN THE EXTREME ENVIRONMENT OF MEFITE D'ANSANTO (SOUTHERN ITALY).	

13:00 - 14:30 LUNCH + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 16:00 SESSION: GT03.1. Soil Greenhouse Gas Fluxes in Agricultural and Forest Systems: Measurements, Synthesis and Modelling

Chairs:
J. Álvaro-Fuentes *(EEAD-CSIC)*
R. Zornoza *(Univ. Politécnica Cartagena)*

14:30 - 14:45	**ORAL 10:**	**P. N. Murphy *et al.*** *Univ.y College Dublin (Ireland)*
	#530.	
	EFFECT OF SWARD COMPOSITION, URINE DEPOSITION AND SEASON ON SOIL N2O EMISSIONS AND HERBAGE YIELD IN A TEMPERATE PASTURE.	
14:45 - 15:00	**ORAL 11:**	**B. S. Just *et al.*** *Univ. of Vic – Central Univ. of Catalonia, Vic (Spain)*
	#607.	
	INTERACTIVE EFFECTS OF CARBON, PHOSPHORUS, AND MOISTURE ON SOIL GREENHOUSE GAS EMISSIONS REVEALED THROUGH AN INCUBATION STUDY.	
15:00 - 15:15	**ORAL 12:**	**M. Mirzaei *et al.*** *Trinity College Dublin (Ireland)*
	#644.	
	MODULATING NITROUS OXIDE EMISSIONS THROUGH GRASSLAND SWARD COMPOSITION: A COMPARATIVE STUDY OF PERENNIAL RYEGRASS AND MULTISPECIES SWARDS.	
15:15 - 15:30	**ORAL 13:**	**D. Fernández-Rodríguez *et al.*** *Univ. de Extremadura, Badajoz (Spain)*
	#721.	
	GREENHOUSE GAS MITIGATION IN RICE CULTIVATION THROUGH HOLM-OAK BIOCHAR APPLICATION AND ALTERNATE WETTING AND DRYING IRRIGATION.	
15:30 - 15:45	**ORAL 14:**	**L. Crosetto *et al.*** *Univ. degli Studi di Torino (Italy)*
	#826.	
	EFFECTS OF ALTERNATE WETTING AND DRYING (AWD) ON DRIVING FACTORS CONTROLLING CH_4 EMISSIONS FROM RICE PADDY SOILS.	
15:45.16:00	**ORAL 15:**	**T. Z. Lerch *et al.*** *IEES-Paris (France)*
	#842.	
	SPATIAL AND TEMPORAL VARIABILITY IN FOREST SOIL COMPACTION EFFECTS ON METHANE FLUXES AND ASSOCIATED BACTERIAL AND ARCHAEAL COMMUNITIES.	



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16:00 - 16:30 COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

16 30 - 18 00 SESSION: GT03.2. Optimizing Roots for Sustainable Crop Production in Europe, Lessons Learnt from EJP Soil and Other Soil Root Studies

Chairs:
J. Mayer *(Agroscope)* / **I. Bertrand** *(INRAE UMR Eco&Soils)* / **R. Hood-Nowotny** *(BOKU)*

16:30 - 16:45	**ORAL 16:**	**K. Bright *et al.*** *EPFL, Lausanne (Switzerland)*
	#145.	
	METAGENOMIC INSIGHTS INTO HOW MICROBIAL METABOLISM SHAPES ORGANIC CARBON CYCLING IN ALPINE RIPARIAN SOILS.	
16:45 - 17:00	**ORAL 17:**	**D. Rasse *et al.*** *Norwegian Inst. of Bioeconomy Res. (NIBIO), Ås (Norway)*
	#383.	
	THE FATE OF ABOVE- VS. BELOWGROUND CARBON INPUT FROM CONTRASTING COVER-CROP SPECIES IN A NORWEGIAN SOIL.	
17:00 - 17:15	**ORAL 18:**	**C. Poll *et al.*** *Univ. of Hohenheim, Stuttgart (Germany)*
	#550.	
	HOW DOES THE COMBINATION OF ROOT-CONTRASTED PHENOTYPES INFLUENCE THE MICROBIAL COMMUNITY AND NUTRIENT FLOW UNDER DIFFERENT WATER REGIMES?	
17:15 - 17:30	**ORAL 19:**	**C. Fernández-Balado *et al.*** *BOKU Univ., Vienna (Austria)*
	#456.	
	ENHANCING BELOWGROUND CARBON INPUTS TO SOIL THROUGH VARIETY SELECTION: A CASE STUDY IN WINTER WHEAT USING A $^{13}CO_2$ MULTIPLE-PULSE LABELLING APPROACH.	
17:30 - 17:45	**ORAL 20:**	**P. Illmer *et al.*** *Univ. Innsbruck (Austria)*
	#536.	
	REDUCED ATMOSPHERIC PRESSURE AFFECTS SOIL MICROORGANISMS IN ALPINE PLANT RHIZOSPHERES.	
17:45 - 18:00	**ORAL 21:**	**I. Bertrand *et al.*** *INRAE UMR Eco&Sols, Montpellier (France)*
	#384.	
	FIELD MEASUREMENT OF NET C RHIZODEPOSITION OF BARLEY, SORGHUM COVER CROP AND PERENNIAL HERBACEOUS ROWS OF A MEDITERRANEAN AGROFORESTRY SYSTEM.	

18:00 - 18:20 FLASH ORAL SESSION GT03

Chair:
P. Murphy *(Univ. College Dublin)*

18:00 - 18:05	**FLASH GT03-1:**	**M. Laub *et al.*** *ETH Zürich (Switzerland) SENIOR*
	#151.	
	SIMULATING THE POTENTIAL TO INCREASE MAIZE YIELDS AND MITIGATE CLIMATE CHANGE BY ADOPTING INTEGRATED SOIL FERTILITY MANAGEMENT ACROSS DIFFERENT REGIONS IN KENYA.	
18:05 - 18:10	**FLASH GT03-2:**	**V. Jílková and M. Libra.** *Biology Centre CAS, Budejovice (Czech Republic) SENIOR*
	#218.	
	DOMINANCE OF TEMPERATURE, CHEMICAL RECALCITRANCE AND ORGANO-MINERAL PROTECTION IN PRIMING EFFECT REGULATION.	



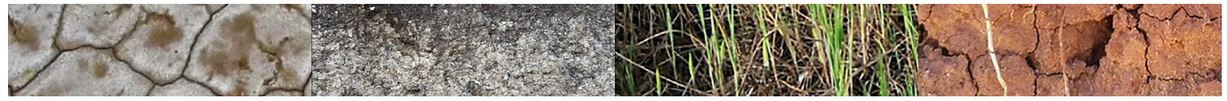
18:10 - 18:15	**FLASH GT03-3:**	**H. Y. Hwang *et al.*** *Nat. Institute of Agric. Sci., Wanju (South Korea)*
	#666.	
	INDIRECT NITROUS OXIDE EMISSIONS FROM REPRESENTATIVE STREAMS IN AGRICULTURAL WATERSHED IN SOUTH KOREA.	
18:15 - 18:20	**FLASH GT03-4:**	
	#TO BE CONFIRMED	

18:30 - 19:00 FLASH ORAL SESSION GT13 & GT16

Chair:
M. García-Carmona *(Univ. Miguel Hernández)*

18:30 - 18:35	**FLASH GT13-1:**	**C. De Feudis *et al.*** *Univ. of Milano-Bicocca (Italy)*
	#738.	
	SOILS IN THE CITY: CHEMICAL AND PHYSICAL PROPERTIES OF GREEN AREAS IN MILAN (ITALY), WITH A FOCUS ON COMPACTION.	
18:35 - 18:40	**FLASH GT13-2:**	**T. Alía López *et al.*** *Univ. Complutense de Madrid (Spain)*
	#457.	
	HEALTHY SOILS, HEALTHY CITIES: ASSESSING SOIL QUALITY IN URBAN GREEN SPACES.	
18:40 - 18:45	**FLASH GT13-3:**	**A. Di Serio *et al.*** *Univ. of Salerno, Fisciano (Italy)*
	#741.	
	ENHANCING URBAN SOIL FUNCTIONALITY THROUGH ORGANIC AMENDMENTS: EFFECTS ON CARBON DYNAMICS, MICROBIAL BIODIVERSITY AND VEGETATION PHYSIOLOGY.	
18:45 - 18:50	**FLASH GT13-4:**	**P. Matias *et al.*** *Univ. of Algarve, Faro (Portugal)*
	#815.	
	THE EFFECT OF SOIL MANAGEMENT PRACTICES ON SOIL CARBON STORAGE IN URBAN GREEN SPACES WITH PINUS PINEA	
18:50 - 18:55	**FLASH GT16-1:**	**K. Crnec and B. Vrščaj.** *Faculty of Environ. Protection, Velenje (Slovenia) SENIOR*
	#436.	
	RAISING SOIL AWARENESS IN PRIMARY AND SECONDARY SCHOOLS THROUGH INDOOR WORKSHOPS - DESIGN AND LESSONS LEARNED.	

20:30 - LATE GALA DINNER



WEDNESDAY 10th SEPTEMBER 2025

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MEZQUITA Hall (Auditorium F, First floor)

09:45 - 11:00 SESSION: GT17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE

Chair:
J. Mataix-Solera *(Univ.Miguel Hernández)*

09:45 - 10:00	**ORAL 01:**	**K. Kalkan *et al.*** *Biosense Institute, Novi Sad (Serbia)*
	#54.	
	THE ROLE OF CITIZEN SCIENCE IN CONNECTING PEOPLE WITH SOIL: A CASE STUDY FROM VOJVODINA, NORTHERN SERBIA.	
10:00 - 10:15	**ORAL 02:**	**R. Castellán *et al.*** *Benemérita Univ. Autónoma de Puebla (Mexico)*
	#818.	
	ANALYSIS OF THE SUSTAINABILITY OF COFFEE PLANTATIONS IN THE MUNICIPALITY OF CUETZALAN DEL PROGRESO, PUEBLA, MEXICO.	
10:15 - 10:30	**ORAL 03:**	**S. Demir** *and* **L. Basayigit.** *Isparta Univ. of Appl. Sci. (Turkey)*
	#828.	
	A SPATIAL ANALYSIS OF HUMAN–SOIL INTERACTIONS USING REMOTE SENSING AND SOIL DATA: IMPACTS OF THE CONFLICT IN UKRAINE ON FOOD SECURITY.	
10:30 - 10 - 45	**ORAL 04:**	**B. Shrestha *et al.*** *Agric. and Agri-Food Canada, Beaverlodge (Canada)*
	#863	
	PEACE REGION LIVING LAB: A MULTI-STAKEHOLDERS INITIATIVE FOR AGRICULTURAL CLIMATE SOLUTIONS.	
10:45 - 11:00	**ORAL 05:**	**A. Gömöri *et al.*** *Hungarian Soil Sci. Soc., Miskolc (Hungary)*
	#856	
	ROOTSS – INTRODUCING OPEN AND RESPONSIBLE RESEARCH AND INNOVATION (ORRI) IN SOIL SCIENCE: A HUNGARIAN CASE ALIGNED WITH THE EU SOIL MISSION.	

11:00 - 12:00 COFFEE + EXPO + POSTERS SESSION 2 (2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 SESSION: GT17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE

Chair:
J. J. Ortega-Calvo *(IRNAS-CSIC)*

12:00 - 12:15	**ORAL 06:**	**K. Tammik *et al.*** *Centre of Estonian Rural Res. and Knowledge, Jõgeva (Estonia)*
	#203	
	SUSTAINABILITY INCENTIVES IN CERTIFIED SEED PRODUCTION: LINKING SOIL HEALTH, MARKET SIGNALS, AND FARMER BEHAVIOR.	
12:15 - 12:30	**ORAL 07:**	**R. González *et al.*** *Univ. de La Salle, Bogota (Colombia)*
	#545.	
	MODIFYING SOILS AND CULTURE AS A RESPONSE TO DYING CHILDREN AND EXTREME WEATHER CONDITIONS BY THE WAYUU INDIGENOUS COMMUNITY IN COLOMBIA.	



12:30 - 12:45	**ORAL 08:**	**L. Circelli *et al.*** *Univ. of Molise, Campobasso (Italy)*
	#679.	
	MICROPLASTICS IN SOIL AND BIOSOLID SAMPLES: QUANTITATIVE ASSESSMENT WITH A NIR SPECTROSCOPY MULTIVARIATE APPROACH.	
12:45 - 13:00	**ORAL 09:**	**D. Pipoyan *et al.*** *Center Ecol.-Noosphere Studies, Yerevan (Armenia)*
	#734.	
	MULTIDISCIPLINARY APPROACH TOWARD SOIL STUDIES: CHALLENGES AND ACHIEVEMENTS FROM ARMENIA.	

13:00 - 14:30 LUNCH + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

14:30 - 15:45 SESSION: GT17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE

Chair:
S. Demir *(Isparta Univ.)*

14:30 - 14:45	**ORAL 10:**	**E. Arellano *et al.*** *Pontificia Univ. Católica de Chile, Santiago (Chile)*
	#662.	
	LOCAL KNOWLEDGE OF SOIL HEALTH IN SMALLHOLDERS AGROECOLOGICAL FARMING SYSTEMS OF THE ANDEAN FOOTHILLS.	
14:45 - 15:00	**ORAL 11:**	**C. Laurent *et al.*** *Free Univ. of Bolzano (Italy)*
	#111.	
	BRIDGING CITIZEN SCIENCE GENERATED DATA AND SOIL LAB ANALYSES: UNDERSTANDING THE VARIABILITY AND INSIGHTS.	
15:00 - 15:15	**ORAL 12:**	**J. Maciulaitis and J. Volungevicius.** *Vilnius Univ. (Lithuania)*
	#126.	
	INTEGRATED LANDSCAPE APPROACH TO AGROECOSYSTEM MANAGEMENT FOR HARMONISING THE USE OF GEOECOLOGICAL AND AGROECOLOGICAL POTENTIAL: INSIGHTS FROM A LITHUANIAN CASE STUDY.	
15:15 - 15:30	**ORAL 13:**	
	To be confirmed.	
15:30 - 15:45	**ORAL 14:**	
	To be confirmed.	
15:45.16:00	**ORAL 15:**	
	To be confirmed.	

16:00 - 16:30 COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)



16:30 - 16:55 FLASH ORAL SESSION GT04

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Chairs:
L. Gismero-Rodríguez *(IG-CSIC)* / **C. Joly** *(CEFE-CNRS)*

16:30 - 16:35	**FLASH GT04-1:**	**M. C Hernandez-Soriano *et al.*** *John Innes Centre, Norwich (United Kingdom)* **SENIOR**
	#586.	
	INNOVATIVE CRISPR SOLUTIONS FOR OPTIMISING NITROGEN MANAGEMENT IN AGRICULTURE – ICON.	
16:35 - 16:40	**FLASH GT04-2:**	**O. Azevedo *et al.*** *Forest Research, Roslin (United Kingdom)*
	#372.	
	BELOWGROUND BIODIVERSITY DYNAMICS DURING WOODLAND DEVELOPMENT: INSIGHTS FROM A UK FOREST CHRONOSEQUENCE STUDY.	
16:40 - 16:45	**FLASH GT04-3:**	**S. Remelli *et al.*** *Univ. of Parma, Parma, Italy SENIOR*
	#425.	
	AGROPHOTOVOLTAIC SYSTEM SHAPES SOIL ARTHROPOD COMMUNITY STRUCTURE: INTERACTIONS BETWEEN MICROCLIMATE, CROP DEVELOPMENT, AND EDAPHIC FACTORS.	
16:45 - 16:50	**FLASH GT04-4:**	**C. Chiodi *et al.*** *Univ. of Padova (Italy) SENIOR*
	#760.	
	TREE SPECIES AND SOIL HORIZONS SHAPE FUNGAL COMMUNITIES IN ITALIAN BEECH AND SPRUCE FORESTS.	
16:50 - 16:55	**FLASH GT04-5:**	**P. R. Guayasamín *et al.*** *Univ. Estatal Amazónica, Puyo (Ecuador)*
	#14.	
	BIOCHAR EFFECTS ON ANT COMMUNITY COMPOSITION IN ENRICHED SECONDARY FORESTS OF THE ECUADORIAN AMAZON.	

17:00 - 17:20 FLASH ORAL SESSION GT14

Chairs:
M. A. Jiménez-González *(Univ. Autónoma Madrid)* / **A.D. Lázaro-López** *(INIA-CSIC)*

17:00 - 17:05	**FLASH GT14-1:**	**G. Belvisi *et al.*** *Univ. of Palermo (Italy)*
	#600.	
	COLLECTION AND HARMONIZATION OF LEGACY SOIL DATA TO SUPPORT DIGITAL SOIL MAPPING IN SICILY (SOUTHERN ITALY).	
17:05 - 17:10	**FLASH GT14-2:**	**D. Sauer *et al.*** *Univ. of Goettingen (Germany)*
	#616.	
	HOW ARE PEOPLE IN EUROPE CONNECTED TO SOIL? OUTCOMES OF A SURVEY ACROSS EIGHT EUROPEAN COUNTRIES.	
17:10 - 17:15	**FLASH GT14-3:**	**P. –H. Wu.** *National Taiwan Univ., Taipei (Taiwan)*
	#84.	
	USING DATA FUSION OF FOUR PROXIMAL SENSORS TO DIAGNOSE HORIZONS AND CLASSIFICATION CATEGORY OF ANDISOLS IN TAIWAN.	
17:15 - 17:20	**FLASH GT14-4:**	**F. Shahbazi *et al.*** *Univ. of Tabriz (Iran)*
	#136.	
	DOES SURFICIAL SOIL COLOR ENHANCE THE ACCURACY OF SOIL SAND CONTENT PREDICTIONS AT TWO STANDARDIZED DEPTHS?	

20:30 - LATE GALA DINNER



THURSDAY 11th SEPTEMBER 2025

AL'ANDALUS Auditorium (Main Auditorium A, Ground floor) 1035

09:30 - 10:15 **PLENARY CONFERENCE**

Title: Soil Biodiversity and Ecosystem Function Under Global Change

Dr. Manuel Delgado-Baquerizo, *(IRNAS-CSIC, Spain)* **(Presented by Dr. M. Muñóz-Rojas)**

10:15 - 11:30 **SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS**

Biostimulants

Chair:
M. Delgado-Baquerizo, *(IRNAS-CSIC)*

10:15 - 10:30 **ORAL 40:** **Y. Bukhonska *et al.*** *Inst. Bioorganic Chem. & Petrochem. NAS, Kyiv (Ukraine)*
#809.
MULTIFUNCTIONAL ROLE OF MICROBIAL BIOLOGICALS IN SOIL RESTORATION AND SUSTAINABLE CROP PRODUCTION.

10:30 - 10:45 **ORAL 41:** **M. T. Gebremikael *et al.*** *Aarhus Univ. (Denmark)*
#654.
THE EFFICACY OF PLANT BIOSTIMULANTS ON SNACK CARROTS YIELD, QUALITY, AND SOIL MICROBIAL ACTIVITIES.

10:45 - 11:00 **ORAL 42:** **L. D. Devia-Grimaldo *et al.*** *Univ. Oública de Nvarra, Pamplona (Spain)*
#393:
UNLOCKING THE POWER OF COMPOST MICROBIOMES FOR SUSTAINABLE AGRICULTURE.

11:00 - 11:15 **ORAL 43:** **L. Baert *et al.*** *Ghent Univ. (Belgium)*
#342.
CHITIN AMENDMENT IN SOIL: EFFECTS OF CHITIN SOURCE AND PARTICLE SIZE ON SOIL PHYSICAL PROPERTIES UNDER VARIABLE ENVIRONMENTAL CONDITIONS.

11:15:11:30 **ORAL 44:** **S. K. Darkaoui *et al.*** *Trichodex, Grupo Fertiberia, Seville (Spain)*
#1134
HARNESSING SOIL MICROBIOMES FOR SUSTAINABLE CROP RESILIENCE.

11:30 - 12:00 **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 **SESSION: GT07. SOIL AMENDMENTS & FERTILIZERS**

Biopolymers

Chair:
M.T. Dominguez *(Univ. Sevilla)* **/ K. Akdi** *(Trichodex-Fertiberia)*

12:00 - 12:15 **ORAL 45:** **S. Paliaga *et al.*** *Univ. Palermo (Italy)*
#401.
FERTILIZER ENRICHED BIO-BASED MULCH FILMS INCREASE NITROGEN AND PHOSPHORUS AVAILABILITY AND STIMULATE SOIL MICROBIAL BIOMASS AND ACTIVITY.



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12:15 - 12:30 **ORAL 46:** **J. Kucerik *et al.*** *Univ. Brno (Czech Republic)*
#732.
ARE BIODEGRADABLE PLASTICS SAFE FOR SOIL APPLICATIONS?

12:30 - 12:45 **ORAL 47:** **M. Prendergast-Miller *et al.*** *Northumbria Univ., Newcastle Upon Tyne (United Kingdom)*
#481.
BIODEGRADATION OF WOOL IN SOIL: TEXTILE CIRCULARITY AND SOIL HEALTH.

12:45 - 13:00 **ORAL 48:** **M. Toleikiene *et al.*** *Lithuanian Res. Centre Agric. & Forestry (Lithuania)*
#524.
OPTIMIZING NITROGEN FIXATION OF LEGUME PLANTS AND IMPROVING THEIR USEFULNESS IN ORGANIC FARMING ECOSYSTEMS USING MICROORGANISMS AND BIOSTIMULANTS

13:00 - 13:40 **AWARDS, CONCLUSIONS & CLOSSING CEREMONY**

13:45-14:15 **FLAMENCO TASTE (Al-Andalus Auditorium)**

14:15 - 15:45 **FAREWELL PARTY**

THURSDAY 11th SEPTEMBER 2025

ITALICA Auditorium (Auditorium B, Fist floor)

10:15 - 11:30 **SESSION: GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING**

Linking Process Modelling and Digital Soil Mapping

Chair:
E. Vaudour *(Univ. Paris-Saclay)*

10:15 - 10:30 **ORAL 13:** **S. Fathololoumi and A. Biswas.** *Univ. of Guelph (Canada)*
#25.
ENHANCING SOIL MOISTURE PREDICTION ACCURACY WITH DIGITAL SOIL MAPPING-BASED COVARIATES

10:30 - 10:45 **ORAL 14:** **P. Scheffer *et al.*** *Utrecht Univ. (The Netherlands))*
#678.
DYNAMIC MODELLING OF HYDROLOGY AND SOIL EROSION TO PROVIDE PROCESS-BASED PREDICTORS FOR DIGITAL SOIL MAPPING.

10:45 - 11:00 **ORAL 15:** **H. Chaif *et al.*** *INRAE, Aix-En-Provence (France)*
#169.
IMPACT OF IMPROVED SOIL PROPERTIES REPRESENTATION IN THE DYNAMIC GLOBAL VEGETATION MODEL LPJML.

11:00 - 11:15 **ORAL 16:** **M. A. Tufail *et al.*** *Univ. of Bern (Switzerland)*
#846.
OPTIMIZING N_2O EMISSION PREDICTIONS: A META-ANALYSIS COMPARING PROCESS-BASED MODELS ACROSS SUB-SAHARAN AFRICAN SOILS.

11:15:11:30 **ORAL 17:** **C. Dönmez *et al.*** *Leibniz Centre for Agric. Landscape Res., Müncheberg (Germany)*
#275.
ADVANCING THE REUSE OF LONG-TERM FIELD EXPERIMENTS DATA THROUGH AN OPEN-ACCESS PLATFORM.



11:30 - 12:00 **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 **SESSION: GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING**

Data Platforms and Digital Soil Mapping for Soil Monitoring

Chair:
P. Scheffer *(Utrecht Univ.)*

12:00 - 12:15 **ORAL 18:** **A. Lázaro-López *et al.*** *INIA-CSIC, Madrid (Spain)*

#682.

INTEGRATION OF THE EUROPEAN SOIL MONITORING NETWORK LUCAS AND THE STATE-WIDE PEPAC: IMPROVING THE PREDICTION OF SOIL ORGANIC CARBON STOCK IN SPAIN.

12:15 - 12:30 **ORAL 19:** **D. Fernández and C. Rodríguez.** *Fléttan, Reykjavík (Iceland)*

#251.

EO-BASED SOIL EROSION MAPPING IN ARCTIC REGIONS.

12:30 - 12:45 **ORAL 20:** **L. Pásztor *et al.*** *Inst. for Soil Sci., HUN-REN Centre for Agric. Res., Budapest (Hungary)*

#726.

FROM GSM-CONFORM PRIMARY SOIL PROPERTY MAPS TO 3D SOIL HYDRAULIC DATABASES AND BEYOND.

12:45 - 13:00 **ORAL 21:** **I. Dridi *et al.*** *Univ. of Tunis El Manar, Tunis (Tunisia)*

#64.

THE SHARING-MED INITIATIVE: STANDARDIZING SOIL SAMPLING METHODOLOGIES FOR IMPROVED AGRICULTURAL SUSTAINABILITY IN THE MEDITERRANEAN.

13:00 - 13:15 **ORAL 22:** **F. Shahbazi *et al.*** *Univ. of Tabriz (Iran)*

#122.

DO ADVANCED MAPPING TECHNIQUES CORRESPOND TO THE SPATIAL VARIABILITY OF SOIL GLOMALIN?

14:15 - 15:45 **FAREWELL PARTY (Ground Floor)**



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RONDA Hall (Auditorium C, First floor)

10:15 - 11:30 **SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY**

Chair:
S. Heinze *(Ruhr Univ. Bochum)*

10:15 - 10:30 **ORAL 22:** **L. Maggioli *et al.*** *Univ. of Almería (Spain)*

#745.

TOWARD SCALABLE BIOCRUST RESTORATION: THE SUCCESSFUL RECIPE FOR CYANOBACTERIAL INOCULUM COLONIZATION.

10:30 - 10:45 **ORAL 23:** **J. Fernandez-Galera *et al.*** *EEZA-CSIC, Almería (Spain)*

#860.

GREENHOUSE GAS FLUXES MEDIATED BY BIOCRUST TYPE IN SEMIARID ECOSYSTEMS.

10:45 - 11:00 **ORAL 24:** **O. Azevedo *et al.*** *Forest Res., Roslin (United Kingdom)*

#755.

LEGACY EFFECTS OF EXPERIMENTAL STRESS ON ECTOMYCORRHIZAL FUNGAL COMMUNITIES IN OAK TREES.

11:00 - 11:15 **ORAL 25:** **M. Caors *et al.*** *CNRS/IRD/CNES, Toulouse (France)*

#374.

DEEP SOIL MICROBIOTA AND THEIR FUNCTIONING: HIDDEN PARTNERS FOR AGROFORESTRY IN THE TROPICS?

11:15 - 11:30 **ORAL 26:** **R. N. Ter Borg *et al.*** *Swedish Univ. of Agricu. Sci., Uppsala (Sweden)*

#302.

QUANTIFICATION OF FIELD EARTHWORM BURROWING RATES USING REGULAR X-RAY SCANNING DURING A GROWING SEASON.

11:30 - 12:00 **COFFEE + EXPO + POSTERS SESSION 2**
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 **SESSION: GT04. SOIL BIOLOGY AND MICROBIOLOGY**

Biodiversity Assessment and Monitoring

Chair:
Monika Toleikiene *(Lituanian Res. Centre Agric. & Forestry)*

12:00 - 12:15 **ORAL 27.** **F. É. Félegyházi *et al.*** *Eötvös Loránd Univ., Budapest (Hungary)*

#853.

DEPTH-RESOLVED MONITORING OF ARBUSCULAR MYCORRHIZAL FUNGAL COMMUNITIES DURING TRANSITION TO REGENERATIVE AGRICULTURE.

12:15 - 12:30 **ORAL 28:** **J. González-Canales *et al.*** *IMIDRA, Alcalá De Henares, Madrid (Spain)*

#359.

SOIL ENZYME ACTIVITY MONITORING THROUGHOUT THE YEAR IN OLIVE ORCHARDS WITH COVER CROPS.



12:30 - 12:45	**ORAL 29:**	**K. Hoeffner *et al.*** *UMR SAS INRAe Institut Agro Rennes-Angers, Rennes (France)*
	#512.	
	CITIZEN-BASED IDENTIFICATION OF EARTHWORM MORPHOTYPES: INSIGHTS FROM A LARGE-SCALE BIODIVERSITY MONITORING NETWORK IN FRANCE.	
12:45 - 13:00	**ORAL 30:**	**G. Bartolomeo *et al.*** *Univ. of Trieste, Trieste (Italy)*
	#73.	
	GRAPHITE FOR GRAPHENE: DIGGING INTO THE DIVERSITY OF PRIMARY DEGRADING MICROORGANISMS	
14:15 - 15:45	**FAREWELL PARTY (Ground Floor)**	

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BAHIA Hall (Auditorium D, First floor)

10:15 - 11:30	**SESSION:**	**GT16. SOIL LITERACY EDUCATION, & ART**
	Chair: **L. B. Reyes-Sánchez** *(Univ. Nacional Autónoma de México)*	
10:15 - 10:30	**ORAL 01:**	**R. Delgado Calvo-Flores *et al.*** *Univ. de Granada (Spain)*
	#905.	
	THE BOOK: SCANNING ELECTRON MICROSCOPY (SEM) OF SOILS AND OTHER MATERIALS. ATLAS OF IMAGES.	
10:30 - 10:45	**ORAL 02:**	**A. I. Machado *et al.*** *Univ. of Aveiro, Aveiro (Portugal)*
	#761.	
	RAISING SOIL LITERACY TO CATALYSE SOCIETAL CHANGES: THE CURIOSOIL APPROACH.	
10:45 - 11:00	**ORAL 03:**	**S. Mantel.** *ISRIC World Soil Information, Wageningen (The Netherlands)*
	#753.	
	TALES OF THE SOIL: STORYTELLING AS A WAY TO INCREASE SOIL LITERACY.	
11:00 - 11:15	**ORAL 04:**	**P. Simoncic *et al.*** *Slovenian Forestry Inst., Ljubljana (Slovenia)*
	#729.	
	SOIL: OURINVISIBLEALLY – PROMOTING SUSTAINABLE SOIL MANAGEMENT THROUGH SCIENCE AND ART.	
11:15 - 11:30	**ORAL 05:**	**R. L. Nánási.** *Found. Art and Nature gGmbH, Bad Heilbrunn (Germany)*
	#561.	
	FORUM NANTESBUCH - LIVING SOILS: AN INITIATIVE OF THE FOUNDATION ART AND NATURE FOSTERING SOIL LITERACY AND STEWARDSHIP ACROSS SOCIETY.	
11:30 - 12:00	**COFFEE + EXPO + POSTERS SESSION 2 (2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)**	



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12:00 - 13:00	**SESSION:**	**GT16. SOIL LITERACY EDUCATION, & ART**
	Chairs: **R. Delgado Calvo-Flores** *(Univ. de Granada)*	
12:00 - 12:15	**ORAL 06:**	**A. Brauman *et al.*** *French Soil Sci. Soc., Orléans (France)*
	#315.	
	SOILSCAPE: SOIL ILLUSTRATED BY SCIENCE AN ART FOR PUBLIC EDUCATION.	
12:15 - 12:30	**ORAL 07:**	**B. Vršcaj and K. Crnec**. *Faculty of Environ. Protection, Velenje (Slovenia)*
	#437.	
	OUTDOOR SOIL EDUCATION: LESSONS FROM SOIL SUMMER SCHOOLS.	
12:30 - 12:45	**ORAL 08:**	**R. Antón *et al.*** *Univ. Pública de Navarra, Pamplona (Spain)*
	#681.	
	BUILDING KNOWLEDGE ABOUT THE SOILS AT THE LOCAL SCALE: THE CASE OF ORDUÑA (SPAIN).	
12:45 - 13:00	**ORAL 09:**	**D. Arenas-Lago *et al.*** *Univ. de Vigo, Ourense (Spain)*
	#652.	
	EDUCATIONAL AND OUTREACH ACTIVITIES OF THE TERRITORIAL DELEGATION OF THE SPANISH SOCIETY OF SOIL SCIENCE (SECS) IN GALICIA.	
14:15 - 15:45	**FAREWELL PARTY (Ground Floor)**	

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MARISMAS Hall (Auditorium E, First floor)

10:15 - 11:30	**SESSION:**	**GT13. LAND FRAGMENTATION, URBAN & ANTHROPOGENIC SOILS**
	Chairs: **P. Simoncic** *(Eslovenian Forest Inst.)* **/ I. Mikajlo** *(IEES-Paris)*	
10:15 - 10:30	**ORAL 01:**	**C. Kabala *et al.*** *Wroclaw Univ of Environ. and Life Sci., Wroclaw (Poland)*
	#196.	
	THE RISK FOR HUMAN HEALTH FROM THE SOILS OF URBAN GARDENS ESTABLISHED IN RECLAIMED CLAY PITS.	
10:30 - 10:45	**ORAL 02:**	**A. Salvucci *et al.*** *Polytech. Univ. of Marche, Ancona (Italy)*
	#318.	
	DE-SEALING OF URBAN SOIL AND CONTAMINATION RISK: A CASE STUDY FROM THE REUSES PROJECT.	
10:45 - 11:00	**ORAL 03:**	**N. Golob *et al.*** *Univ. of Ljubljana (Slovenia)*
	#406.	
	FROM ASH TO AGRO: ASSESSING PROPERTIES OF A THIN TECHNOSOL FOR AGRICULTURAL VIABILITY.	
11:00 - 11:15	**ORAL 04:**	**G. Mastrolonardo *et al.*** *Univ. di Firenze (Italy)*
	#468.	
	USE OF WASTE MATERIALS AS FEASIBLE STRATEGY FOR URBAN DE-SEALED SOIL RECLAMATION: EVIDENCE FROM A RESTORATION CASE STUDY IN PRATO, ITALY.	



11:15 - 11:30	**ORAL 05:**	**M. Coudene *et al.*** *Univ. de Neuchâtel (Switzerland)*
	#836	
	CHARACTERIZATION OF URBAN SOIL STRUCTURE THROUGH X-RAY MCT ANALYSIS.	

11:30 - 12:00 — COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 13:00 — SESSION: GT13. LAND FRAGMENTATION, URBAN & ANTHROPOGENIC SOILS

Chair:
G. Mastrolonardo *(Univ. Firenze)*

12:00 - 12:15	**ORAL 06:**	**I. Mikajlo *et al.*** *iEES-Paris (France)*
	#838.	
	CONSTRUCTING TECHNOSOLS FOR URBAN GREEN SPACES: OPTIMIZING FUNCTIONALITY THROUGH TEXTURE AND ORGANIC MATTER CONTENT.	
12:15 - 12:30	**ORAL 07:**	**T. Künnemann *et al.*** *INRAE, URCA, UMR FARE, Reims (France)*
	#387.	
	LITTER C:N RATIO AND SOIL WATER RETENTION DRIVE EARLY CO_2 AND N_2O EMISSIONS FROM RECYCLED LITTER ON URBAN LAWNS.	

14:00 - 15:30 — FAREWELL PARTY

THURSDAY 11th SEPTEMBER 2025

MEZQUITA Hall (Auditorium F, First floor)

10:15 - 12:45 — WORKSHOP — Evenor Tech:

From Zero to Hero: Practical Insights into Living Labs and Lighthouses for Soil Management

Chairs:
D. Soto-Gómez *(Univ. of Burgos)* / **F. J. Blanco-Velázquez** *(Evenor-Tech)*
F. Á. González-Peñaloza *(Evenor-Tech)* / **Y. Chourak** *(BETA Tech. Center)*

10:15 - 10:30	**Welcome and Introduction**
10:30 - 10:50	**Conceptual Foundations: From concept to practice What are Living Labs and Lighthouses?**
10:50 - 11:50	**CASE STUDIES:**

J. Silva *(Ecoterrae)*

Cost - effective Soil Carbon Monitoring for Carbon Farming

Y. Chourak *et al.* *(Univ. de Vic)*

The Catalan Living Lab of the DeliSoil Project: A Multi - Stakeholder Initiative for Advancing Soil Health within a Circular Economy Framework



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D. M. Ribeiro-Santos *(Food4sustainability)*

LILAS4SOILS: Carbon Farming in the Mediterranean Region

M. Jurado-Rodríguez *(Univ. de Jaén)*

Andalusian Living Lab – LivingSoiLL: Transition Towards Healthy Soils in More Resilient and Productive Olive Groves in Andalusia

C. C. Ribeiro-Carlos *(Univ. Trás-os-Montes and Alto Douro)*

To be confirmed.

11:50 - 12:00 — COFFEE + EXPO + POSTERS SESSION 2
(2A - ground floor: GT 3,4,6, 13 & 16; 2B- first floor: GT 7, 14 & 17)

12:00 - 12:30	**Roundtable & Open Discussion**
12:30 - 12:45	**Wrap-up & Next Steps**

14:15 - 15:45 — FAREWELL PARTY (Ground Floor)

SUMMARY OF THE DAILY PROGRAM

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MONDAY 8th September

	AL ANDALUS AUDITORIUM (A, Ground floor)	ITALICA AUDITORIUM (B, First floor)	RONDA HALL (C, First floor)	BAHIA HALL (D, First floor)	MARISMAS HALL (E, First floor)	MEZQUITA HALL (F, First floor)
08:15	Registration Open					
9:00-10:00	**Opening and presentation / Opening conference** Dr. Panos Panagos *(EC JRC; Italy)*					
10:00-10:45	**Inaugural conference** Dr. Rattan Lal *(Ohio State Univ. USA)*					
10:45-11:30	**Coffee+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EUSO, 1, 2, 5, 8, 10 & 12)					
11:30-13:00	**GT09. SOIL HEALTH** Conceptual Frameworks & Assessment I	**GT07. SOIL AMENDMENTS AND FERTILIZERS:** Circular Economy Approaches… I	**GT10. SOIL CARBON DYNAMICS & STABILIZATION I**	**GT11. SOIL DEGRADATION, DESERTIFICATION**	**GT02. SOIL PHYSICAL CHEMISTRY** Soil structure and physical modelling	**GT05. SOIL HYDROLOY & EROSION**
13:00-14:30	**Lunch+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EU, 1, 2, 5, 8, 10 & 12)					
14:30-16:00	**GT09. SOIL HEALTH** Carbon and Nutrient Cycling	**GT07. SOIL AMENDMENTS AND FERTILIZERS:** Circular Economy Approaches… II	**GT10. SOIL CARBON DYNAMICS & STABILIZATION II**	**GT11. SOIL DEGRADATION, DESERTIFICATION:** Emerging pollutants and microplastics I	**GT02. SOIL PHYSICAL CHEMISTRY** Biogeochemical cycles and soil contaminants	**GT12. SOIL NATURAL HAZARDS:** FIRES, FLOODINGS, LANDSLIDES.
16:00-16:30	**Coffee+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EUSO, 1, 2, 5, 8, 10 & 12)					
16:30-18:00		**GT07. SOIL AMENDMENTS AND FERTILIZERS:** Circular Economy Approaches… III	**GT10. SOIL CARBON DYNAMICS & STABILIZATION** Land Uses for Carbon Enhancement"	**GT11. SOIL DEGRADATION, DESERTIFICATION:** Emerging pollutants and microplastics II	**FLASH ORAL SESSION GT 01 (till 17:00) FLASH ORAL SESSION GT 11 & GT02**	**FLASH ORAL SESSION GT 09 (till 17:05) FLASH ORAL SESSION GT 10**
18:00-19:00			**WORKSHOP 1. SOIL HEALTH INSTITUTE**	**WORKSHOP 2. BSSS (P.Hallet & A. Morris)**		
19:05-20:00	**WELCOME CONCERT** (Al Andalus Auditorium)					
20:00-21:00	**SPANISH WINE**					

TUESDAY 9th September

	AL ANDALUS AUDITORIUM (A, Ground floor)	ITALICA AUDITORIUM (B, First floor)	RONDA HALL (C, First floor)	BAHIA HALL (D, First floor)	MARISMAS HALL (E, First floor)	MEZQUITA HALL (F, First floor)
9:00-9:45	**Plenary conference** Dr. Claire Chenu *(INRAE, France)*	**Plenary conference** Prof. Laura B. Reyes Sánchez *(Univ. Aut. Mexico)*				
9:45-11:00	**GT09. SOIL HEALTH** Management and Climate Strategies I	**EUSO 5th Stakeholders Forum**	**GT10. SOIL C DYNAMICS & STABILIZATION** Carbon Characterization at the Pedon to Micro Scale, and Linking to the Landscape Scale I	**GT11. SOIL DEGRADATION, DESERTIFICATION:** Digital Tools and Monitoring	**GT01. SOIL GENESIS, EVOL…** Soil Genesis, Properties, and Classification Challenges	**GT08. SOIL, PLANT, WATER INTERACTIONS**
11:00-12:00	**Coffee+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EUSO, 1, 2, 5, 8, 10 & 12)					
12:00-13:00	**GT09. SOIL HEALTH** Management and Climate Strategies II	**EUSO 5th Stakeholders Forum**	**GT10. SOIL C DYNAMICS & STABILIZATION** Carbon Characterization at the Pedon to Micro Scale, and Linking to the Landscape Scale II	**GT11. SOIL DEGRADATION, DESERTIFICATION** Amendments and Soil Remediation	**GT01. SOIL GENESIS, EVOL…** Soils Though Time: From the Past to the Future I	**GT08. SOIL, PLANT, WATER INTERACTIONS**
13:00-14:30	**Lunch+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EU, 1, 2, 5, 8, 10 & 12)					
14:30-16:00	**GT09. SOIL HEALTH** Monitoring Networks and Data Platforms	**EUSO 5th Stakeholders Forum**	**GT10. SOIL C DYNAMICS & STABILIZATION** Management Practices and Soil Health	**GT11. SOIL DEGRADATION, DESERTIFICATION:** Phytoremediation	**GT01. SOIL GENESIS, EVOL…** Soils Though Time: From the Past to the Future II	**GT08. SOIL, PLANT, WATER INTERACTIONS**
16:00-16:30	**Coffee+ expo + posters session I** (IA - ground floor-posters: GT9 & 11; IB- first floor- posters: GT EUSO, 1, 2, 5, 8, 10 & 12) / end of poster session I					
16:30-18:00	**GT09. SOIL HEALTH** Monitoring Networks (cont.) / Physical Structure and Hydrology	**GT17.2 Digital Soil Mapping and Innovative Soil Monitoring Systems in the EU**	**GT10. SOIL C DYNAMICS & STABILIZATION** Effects of Soil C Content in Soil Health	**GT11.3.** Soil Degradation in Mining and Industrial Areas: Assessment, Remediation, and Prevention Strategies	**GT01. SOIL GENESIS, EVOL…** Advances in Soil Mapping	**GT08.1.** Linking Vegetation Indices and Soil Properties: Advances in Measurement, Monitoring, and Modelling
18:00-19:00		**GT17.2 Digital Soil Mapping and Innovative Soil Monitoring Systems in the EU**	Spanish Society of Soil Sciences **GENERAL ASSEMBLY**	**WORKSHOP 3. STEVENS + SOIL MOISTURE**	**FLASH ORAL SESSION GT 08, & GT12 till 18:15**	**FLASH ORAL SESSION GT 07**

WEDNESDAY 10th September

	AL ANDALUS AUDITORIUM(A, Ground floor)	ITALICA AUDITORIUM (B, First floor)	RONDA HALL(C, First floor)	BAHIA HALL (D, First floor)	MARISMAS HALL (E, First floor)	MEZQUITA HALL (F, First floor)
09:00-09:45	**Plenary conference** Dr. Peter Schad *(Technical University of Munich, Germany)*	**Plenary conference** Prof. Heike Knicker *(IG-CSIC, Spain)*				
09:45-11:00	**Status of the Soil World's Soil Resources Report 2025** (SWSRR) (FAO-GSP)	**GT07. SOIL AMENDMENTS AND FERTILIZERS** Mineral Fertilization I	**GT14. SOIL DATA ACQUISITION, CURATION,** SHARING & MODELLING (Remote Sensing)	**GT04. SOIL BIOLOGY.** Effects of Land Management on Soil Biota I	**GT03. SOIL BIOGEOCHEMISTRY.** Changing Environment and Land-Use	**GT17.** SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE
11:00-12:00	**Coffee+ expo + posters session 2** (2A- ground floor-posters: GT 3,4,6, 13 & 16; 2B- first floor- posters: GT 7, 14 & 17)					
12:00-13:00	**GT09. SOIL HEALTH.** Biological and Biodiversity Indicators	**GT07. SOIL AMENDMENTS AND FERTILIZERS** Mineral Fertilization II	**GT10. SOIL C DYNAMICS & STABILIZATION** Amended Soils	**GT04. SOIL BIOLOGY** Effects of Land Management on Soil Biota II	**GT03. SOIL BIOGEOCHEMISTRY**	**GT17.** SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE
13:00-14:30	**Lunch + expo + posters session 2** (2A- ground floor-posters: GT 3,4,6, 13 & 16; 2B- first floor- posters: GT 7, 14 & 17)					
14:30-16:00	**GT09. SOIL HEALTH**	**GT07. SOIL AMENDMENTS AND FERTILIZERS** Chars as Soil Amendments & Impact on the Soil-Plant-Microorganism System I	**GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING** (Proximal Sensing)	**GT04. SOIL BIOLOGY** Effects of Land Management on Soil Biota III	**GT03.1.** Soil Greenhouse Gas Fluxes in Agricultural and Forest Systems: Measurements, Synthesis and Modelling	**GT17.** SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE
16:00-16:30	**Coffee+ expo + posters session 2** (2A- ground floor-posters: GT 3,4,6, 13 & 16; 2B- first floor- posters: GT 7, 14 & 17)					
16:30-18:00	**GT09. SOIL HEALTH** Conceptual Frameworks & Assessment II	**GT07. SOIL AMENDMENTS AND FERTILIZERS** Chars as Soil Amendments & Impact on the Soil-Plant-Microorganism System II"	**GT10. SOIL C DYNAMICS & STABILIZATION** Forest Soils	**GT04. SOIL BIOLOGY.** Dynamics and Drivers	**GT03.2.** Optimizing Roots for Sustainable Crop Production in Europe, Lessons Learnt from EJP Soil and Other Soil Root Studies	**FLASH ORAL SESSION GT 04** 16:30-17:10
18:00-18:30			**ECSSS GENERAL ASSEMBLY**		**FLASH ORAL SESSION GT 03**	**FLASH ORAL SESSION GT14** (17:20-17:50)
18:30-19:30					**FLASH ORAL SESSION GT13 & GT16** (18:30-19:00)	
20:30-LATE	**GALA DINNER** (Abades Restaurant; Calle Betis)					

THURSDAY 11th Sept

	AL ANDALUS AUDITORIUM (A, Ground floor)	ITALICA AUDITORIUM (B, First floor)	RONDA HALL (C, First floor)	BAHIA HALL (D, First floor)	MARISMAS HALL (E, First floor)	MEZQUITA HALL (F, First floor)
09:30-10:15	**Plenary conference** Dr. Manuel Delgado-Baquerizo *(IRNAS-CSIC, Spain)*					
10:15-11:30	**GT07. SOIL AMENDMENTS & FERTILIZERS.** Biostimulants	**GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING**	**GT04. SOIL BIOLOGY**	**GT16. SOIL LITERACY EDUCATION, & ART**	**GT13. LAND FRAGMENTATION, URBAN & ANTHROPOGENIC SOILS**	**Evenor Tech: From Zero to Hero:** Practical Insights into Living Labs and Lighthouses for Soil Management
11:30-12:00	**Coffee+ expo + posters session 2** (2A- ground floor-posters: GT 3,4,6, 13 & 16; 2B- first floor- posters: GT 7, 14 & 17)					
12:00-13:00	**GT07. SOIL AMENDMENTS & FERTILIZERS.** Biopolymers	**GT14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING** (12:00-13:15)	**GT04. SOIL BIOLOGY.** Biodiversity Assessment and Monitoring	**GT16. SOIL LITERACY EDUCATION, & ART**	**GT13. LAND FRAGMENTATION, URBAN & ANTHROPOGENIC SOILS** (12:00-12:30)	**Evenor Tech (cont.)**
13:00-13:40	**AWARDS, CONCLUSIONS & CLOSSING CEREMONY**					
13:45-14:15	**TASTE OF FLAMENCO**					
14:15-15:45	**FAREWELL PARTY**					



PLENARY CONFERENCES



Plenary conferences

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The Soils of Our Planet – A Fascinating Resource

PETER SCHAD*

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The soils of our planet are extremely diverse. They depend on the factors of soil formation (climate, parent material, topography, biota, age), which cause many different processes of soil formation. Velocity of soil formation is higher with higher temperatures and higher humidity, and soils develop faster in humid tropical regions than under cold and/or arid climates. Permafrost conditions give the soils unique shapes. Old soils (e. g. on remnants of the Gondwana continent in tropical regions) differ largely from young soils (e. g. in postglacial areas). Parent materials may provide many or little plant nutrients. If many are provided, they may be maintained in the soil or not. Soils may allow a high water percolation or may cause water stagnation. They may be influenced by upward-moving groundwater. If strong reducing conditions occur, they always rule soil formation and use. Water, nutrients and root penetrability determine differences in vegetation, which, in turn, is the major source of organic residues. The residues may be decomposed fast or slowly and may be stabilized or not, resulting in different amounts and qualities of soil organic matter. Plant growth and plant residues are the major source of life for soil animals. Presence and activity of mixing animals largely decide on presence and character of organic surface layers. Animals are an important force of aggregate formation. From the human point of view, many soils are naturally infertile - they are healthy but allow only little production. Land use often decreases soil fertility and organic matter stocks. But since thousands of years, humans struggle for increasing fertility. Nice examples are paddy soils or the terra preta. And human activity may create completely new soils in urban, industrial, traffic, mining and military areas with new parent materials and specific soil-forming processes.

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International Union of Soil Sciences, Vienna. 236 pages.

Schad P (2023): World Reference Base for Soil Resources - Its fourth edition and its history. Journal of Plant Nutrition and Soil Science. https://onlinelibrary.wiley.com/doi/10.1002/jpln.202200417

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Soil biodiversity and ecosystem function under global change

MANUEL DELGADO-BAQUERIZO *

Laboratorio de Biodiversidad y Funcionamiento Ecosistémico, Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS), Consejo Superior de Investigaciones Científicas (CSIC), Sevilla, Spain

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Soil organisms represent the most abundant and diverse organisms on the planet, driving nearly all known ecosystem functions. Their well-documented contributions to soil fertility and carbon sequestration are vital for food security and climate change regulation. Beyond this, soil biodiversity is further integral to One Health and the to the conservation of historic structures such as monuments. Despite their importance, soil biodiversity is highly vulnerable to an increasing number of multiple global change stressors. Research is urgently needed to elucidate how soil biodiversity and function will respond to future environmental shifts. This presentation will highlight the essential role of soil biodiversity in ecosystem services and One Health, and discuss critical knowledge gaps that must be filled to ensure its conservation of soil biodiversity for the next generations.

REFERENCES

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Biochar a magic soil amendment or how does it affect soil biochemistry?

HEIKE KNICKER*, FRANCISCO JESUS MORENO-RACERO, ALVARO FERNANDO GARCÍA RODRIGUEZ, JOSÉ MARÍA GARCÍA DE CASTRO BARRAGAN, LAURA GISMERO RODRÍGUEZ

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In soil science, the term ‘black carbon’ is frequently employed to denote a continuum of pyrogenic organic materials (PyOM) that goes beyond the original description of soot and soot-like compounds derived from the secondary condensation of volatiles formed during heat treatment[1]. It encompasses thermally slightly to heavily altered organic residues accumulating on soils after fire, but also biochar (BC) or hydrochar artificially produced by pyrolysis. It is important to note that PyOM is an ubiquitous entity of soil organic matter (SOM) and, as such, it has a considerable impact on soil ecological functions, biochemical processes within the soil and within biogeochemical cycles.

A distinctive property of PyOM is its high aromaticity; however, recent findings have revealed that the commonly stated highly-polycondensed aromatic nature cannot be considered as an universal feature of PyOM [2]. Whereas the latter is characteristic for soot or BC produced above 600°C, the aromatic network of chars formed at lower temperatures includes domains of furan derivatives, and in the case of N-rich chars, pyrrole- and pyridine-based structures [3]. Although such components are likely to lower the biochemical resistance of the respective PyOM, their turnover in soils is less efficient than the degradation of fresh plant residue or compost [4], thereby still underscoring the potential of PyOM as a mitigating tool for greenhouse gas emissions and increasing C sequestration.

It is widely acknowledged that the incorporation of PyOM into soil can enhance soil quality. In order to take advantage of the positive aspects of PyOM but avoiding the negative consequences of its production through open vegetation fire, BC receives more and more attention as a “clean” alternative soil amendment. However, here it should be noted that the impact of BC on soil quality and crop production is contingent on its chemical and physical properties, and thus depends on the feedstock and the charring conditions.

Nevertheless, even BC is not an inert entity that remains unaffected by soil properties, but depending on the latter will experience aging. During this process, both chemical and physical alterations of its structure can affect its longevity and thus its function as C sink in soil. Oxidation and fractionation may promote leaching into deeper soil horizons or even their biochemical turnover. Respective indications for such a behavoir have been evidenced through subsoil accumulation of oxidized char residues in fire-prone ecosystems [5] in fire-prone ecosystems and in biodegradation studies [6,7].

As demonstrated by new results of our group, the complexity of interactions between the soil compartment and biochar also embraces the composition and activity of the soil microbiome. Thus, it is expected that on a long term, the biochemical processes will not remain unaffected. There are indications that the presence of BC can also affect plant physiology and metabolism although the mechanisms behind these interactions are still unclear [8].

These examples, presented and discussed with this presentation underscores the necessity to consider that BC application to soil cannot be taken as a generalized “one-size serves-all” paradigm but requires careful consideration of the properties inherent to each distinct BC, and how those properties might remedy a specific soil deficiency or alter soil biochemical processes and SOM characteristics.

ACKNOWLEDGEMENTS

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Soil Science and Global Issues of the 21st Century

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Introduction:

The humanity has arrived at a critical crossroads during the Anthropocene. Humans are the most dominant among millions of species of life on earth, and are the major cause of soil degradation, water pollution, air contamination, global warming, and extinction of species on earth. The objective of this article is to deliberate the importance of soil science in addressing global issues of the 21st century.

Material and Methods



The information presented in this article is collected and synthesized from literate on soil science published in peer-reviewed scientific journal articles, specialized soil reports from government agencies, specialized soil science reference books in Web of Science, Google Scholar, Science Direct, and other reports

Results:

Collation and synthesis of literature show ten critical global issues of the 21st century which are strongly related to soil science. These issues include: 1.) human population of 8.2 billion and increasing at the rate of 0.87% per year (5-95 million/month, 71 million/year), 2.) per capita arable land area of 0/176 ha and may decrease by 2050, 3.) soil degradation affecting a large proportion of land and increasing, 4.) 1.8 billion people experiencing water scarcity and increasing because of climate change, 5.) atmospheric concentration of CO2 at 427 ppm and increasing 2.2 ppm /yr, 6.) global energy use of 673 EJ and increasing by 1.4%/year, 7.) global per capita grain production of 358 kg/year and may decrease because of soil degradation and climate change, 8.) food insecure population of 2.8 billion who cannot afford an adequate amount of safe and healthy diet, and global hunger affecting 733 million people in 2025, 9.) per capita CO2 emission of 4.7Mg in the world and 14.2 Mg in the USA, and 10) growing economic inequality and increasing refugees because of political instability and war. Soil degradation has direct and indirect impacts on these and other global issues, which are also determinants of human health and wellbeing. There is a strong need for implementation of a “Soil Health Act” at local,state,national,continental and global scale to protect ,restore and manage soil health.Indeed, soil health matters immensely in addressing these global issues.

Conclusion:

Soil resources of the world are finite,fragile to land misuse and soil mismanagement .Thus, Protection, restoration, and sustainable management of soil health is critical to addressing these and other global issues. Indeed, soil health and its management matters in maintaining global peace and harmony. Achieving long-lasting peace is a scientific issue and based on properties and management of the world’s soils.Soil organic matter content is the heart of soil health. Thus, carbon farming and sequestration of carbon is important to mitigation and adaptation of climate change and making agriculture a part of the solution to addressing global issues.

KEY WORDS:

Global issues, Soil Health, Food Security, Climate Change, World Peace, Human Wellbeing

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Beneath the surface, beyond the targets: soil carbon science for eu policies development

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In recent years, soils and soil carbon are increasingly being considered in policies at different levels. At the European scale, the European Commission is currently progressing a proposal for a Soil Monitoring and Resilience Directive, while a Carbon Removals and Carbon Farming Certification Framework and a Nature Restoration Law have been adopted and entered into force. These landmark policy initiatives demand a wealth of knowledge, such as robust carbon-related indicators, alongside their associated targets and thresholds, reliable estimates of carbon sequestration potentials, and effective measuring, reporting, and verification systems. Furthermore, there is strong need for stabilized and unambiguous terminology, authoritative, context-specific information, and harmonized methodologies. This keynote will present examples from this challenging science-policy interface, demonstrating how cutting-edge soil organic matter research contributes significantly to the development of both soil and climate policies.

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Educating for a sustainable future: environmentally livable, economically viable, and socially and humanly equitable

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Soil is the natural habitat of an immense number of organisms and microorganisms, and therefore, a source of biodiversity; filters, recirculates, and defines the distribution of water; is a waste deposit; reserves and captures carbon to mitigate climate change, and an excellent catalyst in Green Chemical reactions and therefore a real path to reduce pollutants to the environment. Soil is a natural resource, but also a social, economic, cultural, political and patrimonial good of mankind and the loss of all these soil functions and capacities directly affects the sustainability of ecosystem services which are indispensable for human life.

Soil is not only a limited resource but also a limiting one, because without fertile soil there are no plants or animals to eat, no water to drink, no oxygen to breathe, that is, no life or development to reach or sustain. The soil is therefore the natural resource essential to preserve in order to achieve sustainable development (Reyes-Sánchez, 2018).

For all these reasons the protection of the soil resource and an interdisciplinary and innovative education and practice of sciences to raise citizens’ awareness on the importance of its preservation are key to the existence of life on the planet.

Modern soil science has become quite interdisciplinary and even transdisciplinary in its nature knowledge. This makes it necessary to expand our vision for soil science education to include coursework that provides inter- and transdisciplinary values, thoughts, procedures, and actions that will allow the future soil scientists to address social, economic and environmental problems in order to achieve true development for all (Reyes-Sánchez, 2024) as a guarantee of a future environmentally livable, economically viable, and socially and humanly equitable for humanity.

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Improving Soil Health in Europe: Emerging Challenges and Opportunities for Soil Science and Policy

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In Europe, soil health is facing emerging challenges that require innovative solutions and policy interventions. We acknowledge that 62% of the European Union (EU) soils are not in healthy condition, while we face serious challenges such as climate change, food security, biodiversity loss, and socio-economic pressures. The severity of these issues is evident in the fact that soil erosion is unsustainable for around ¼ of the EU territory, carbon stocks in soils are declining, nutrients are depleting, and emerging contaminants can pose a serious threat to soil and human health. The costs of soil degradation in the EU may reach up to 70 Billion Euros per year, highlighting the urgent need for action.

To address these challenges, the EU has put in place many policies for agro-environmental protection since 2000, including soil protection. The European Green Deal, launched in 2020, has set an ambitious roadmap to make the EU the first carbon-neutral continent with a modern, competitive, and resource-efficient economy. As part of the Green Deal, the European Commission (EC) has put soil protection in a high position on the EU policy agenda, recognizing that healthy soils are essential to achieve climate neutrality, zero pollution, sustainable food provision, and a resilient environment. This increased focus on soil health has led to the development of new policies and initiatives, such as the proposal for a Soil Monitoring and Resilience Law, which aims to establish a common framework for monitoring and assessing soil health.

The proposed Soil Monitoring and Resilience Law, tabled by the European Commission in July 2023, lays down measures for monitoring and assessing soil health, managing soils sustainably, and restoring contaminated sites. The European Parliament’s adoption of the Commission proposal in 2024, followed by a positive vote from the European Council, demonstrates the EU’s commitment to addressing soil health. The recent preliminary agreement on the final text of the Law, reached in April 2025, marks a significant step towards implementing effective soil protection policies. Furthermore, the Soil Mission, which aims to set up 100 Living Labs to promote sustainable land and soil management in urban and rural areas, will play a crucial role in achieving the objective of healthy soils by 2050. With an estimated investment of nearly €1 billion until 2028, funded research projects under the Soil Mission are expected to reverse soil degradation through action on the ground, underpinned by the development and monitoring of a set of indicators.

In addition to these initiatives, the Carbon Removals and Carbon Farming (CRCF) regulation is the first EU volunteer framework for certifying carbon removals and carbon farming. This regulation will monitor, report, and verify carbon removals, soil emission reduction, and biodiversity benefits, providing a new opportunity for farmers and other stakeholders to contribute to climate change mitigation. The carbon farming framework can also serve as an



interesting business model for additional income to farmers, while involving diverse actors such as certification bodies, auditors, tech industry, and creating new jobs. By promoting sustainable land use practices, the CRCF regulation can help to sequester carbon, reduce greenhouse gas emissions, and improve soil health.

The adoption of regenerative agriculture practices is also crucial for transforming the agricultural sector and contributing to a more sustainable food system. By adopting practices backed by high-effective biological inputs, farmers can holistically enhance not only soil fertility but also plant health and crop yields. Regenerative agriculture has the potential to promote soil carbon sequestration, reduce synthetic fertilizer use, and increase biodiversity, ultimately contributing to a more resilient and sustainable food system.

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EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



EUSO - 192 - O

GRÓJEC LIVING LAB: CO-CREATION FOR SUSTAINABLE SOIL MANAGEMENT IN PRACTICE

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The Grójec region where Grójec Living Lab is established is located in the southern part of the Mazowieckie Voivodeship and covers an area of 1268 square kilometers with a population of around 100 000 inhabitants. The landscape is dominated by lakeless plains composed of sand and glacial till, from which Luvisols have developed. Grójec region is called the biggest orchard in Europe. The predominant direction of agricultural production in the county is apple orchards, with a very long history dating back to the beginning of the 16th century. Currently, in the Grójec area, apple orchards are very intensive with trees dwarfing rootstocks and covering around 40K ha, providing approximately 40% of the national production of apples. The average apple production stands at 700-800 thousand tons, accounting for the highest share of the national production.

Apple monoculture can lead to soil degradation, nutrient imbalance, and poor soil fertility over time, loss of soil microorganisms' biodiversity, pesticide residue accumulation, and reduction of soil organic matter content. Grójec Living Lab has set itself the goal of developing and presenting the most appropriate methods to eliminate or mitigate these threats to soils by: a) appropriate fertilizer inputs, based on soil and site properties, b) solutions to limit the application of pesticides and c) to improve the quality of organic matter resources (use of different mulches) instead of herbicides to control weeds in tree rows. In all cases, the proposed solutions will be tested against a control situated in the same farm to ensure both scientific validity and visibility for demonstration.

Warsaw University of Life Science (WULS) acts as the LL leader, in collaboration with partners: Grójec Orchards Association (GOA), The Fruit (TFT), Timac Agro Polska (TP), Life BIO Farma (LBF), Woman in the orchard (WO), and fruit growers implement all stages and goals of Grójec LL and the project. The partners' cooperation includes: co-designing the LL and experimental site (EXPS), co-creation of the LL and 10 EXPS, co-identifying threats to soil, co-introducing and testing innovative solutions for soil health, and joint, wide dissemination of the obtained practices that determine soil health. WULS is the bridge between researchers and farmers, following all experiments and all co-creation processes planned, and also providing technical support to EXPS. GOA and TFT inform and engage local farmers and practitioners supporting the identification of EXPS, to promote meetings for the co-creation processes and collect their collaboration and inputs for the planned activities in the LL. The identification and work on EXPS will also be supported by the associated partners (TP, LBF, and WO). All partners in the LL will participate in technical visits to other EXPS (within the LL and also from other LL), capacity building actions and knowledge exchange (online and onsite) meetings.

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TOWARDS HEALTHIER SOILS THROUGH ECHO: CITIZEN ENGAGEMENT, PROGRESS AND PRELIMINARY RESULTS

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 16. CONNECTING PEOPLE AND SOILS

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ECHO is a citizen science project actively engaging citizens in soil science. Building on this participatory approach, the project is encouraging citizen participation in soil protection and restoration, by enhancing knowledge and interest in soil health-related issues, as well as in data collection, by empowering them to contribute to soil science and generate knowledge for the benefit of all. As the project progresses, citizens will be also able to foster behavioural change across the EU, by taking an active role in decision-making on soil issues.

The project supports research and innovation through Horizon Europe's Mission Soil for 2030. ECHO stands out as the only European project entirely dedicated to citizen science among the initiatives funded by the Mission Soil, making significant contributions towards connecting citizens and soils through its initiatives.

To date, the project's activities have mainly focused on meticulously designing the citizen science initiatives and engagement strategies. A review of the state of the art of similar projects has been conducted to leverage existing knowledge. The citizen science method has been co-created with ECHO Ambassadors, and easy-to-understand sampling protocols have been featured. Additionally, the ECHO App has been developed to facilitate the sampling procedure covering all the soil health indicators, and incorporate the results in the ECHOREPO, an online repository that is already publicly accessible.

Nine citizen science initiatives are being launched in nine countries and will be replicated in the remaining 19 EU member states by 2027. They consider different land uses, soil types, and biogeographical regions, as well as the needs of different citizen groups. The ECHO Ambassadors, acting as intermediaries for citizens, together with the ECHO team, are facilitating activities by leading local initiatives and distributing the toolkits.

Preliminary results from the launch of these nine citizen science initiatives include the Ambassador's activities, initial citizen participation and engagement rates, an assessment of the sampling methodology based on early participant feedback, details of the ECHO app and the ECHOREPO ensuring their possible replicability, and preliminary interpretation of responses to the pre/post attitude and knowledge surveys, aimed at increasing public awareness of soil health.

ECHO aims to assess a total of 16,500 sites, contributing valuable data to the ECHOREPO. This repository is directly linked to the EU Soil Observatory (EUSO), enhancing the availability of local-scale citizen science data on soil health. By expanding and complementing this and other existing soil databases, our data will support critical landscape decisions and policy development at the European level.

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DEVELOPMENT AND OPTIMIZATION OF HIGHLY EFFECTIVE AND INNOVATIVE BIOSTIMULANT GRANULATES FORMULATIONS FOR HORTICULTURE.

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Massive agricultural production is required to feed the increasing global population. Moreover, to comply with the United Nations sustainable development goals, new crop performance enhancers are needed to avoid the current extensive use of agrochemicals, which causes environmental pollution [1]. To solve this, biostimulants will play a key role.

Plant biostimulants are substances or microorganisms applied to plants to enhance their growth, regardless of their nutrient content [2]. A promising subset are humic substances, which are constituent fractions of the organic matter of soil and are biologically active [3]. On the other hand, biochar, a C-rich solid, can reduce nutrient leaching and improve soil microbial activity, thus increasing crop yields [4]. These elements can be encapsulated to protect and deliver them more efficiently, minimising environmental disruption and loss of costs, while combining their properties. Nevertheless, some of the current encapsulation techniques in agriculture involve the use of non-biodegradable materials, leading to microplastic pollution [5], and processes used tend to be costly [6].

In this study, sustainable biostimulant macrocapsules, based on biodegradable polymer (i.e., alginate), loaded with artificial humic acids (AHAs) and biochar, are prepared by the coacervation method. Different concentrations of CaCl2 in the crosslinking bath used to crosslink alginate, as well as the possibility of adding an external biopolymer layer, are studied to achieve high encapsulation efficiency and optimal release behaviour. The influence of AHAs and biochar concentrations on macrocapsules formation is also evaluated.

Moreover, before the macrocapsules development, a preliminary study on the phytotoxicity of AHAs and the biopolymer to lettuce has been conducted, showing no phytotoxic effects in the form of seedling burns or yellowing. Furthermore, different concentrations of AHAs have been applied to lettuce seedlings, both via root and foliar application, to evaluate their effectiveness as biostimulants on plant development in comparison to conventional products.

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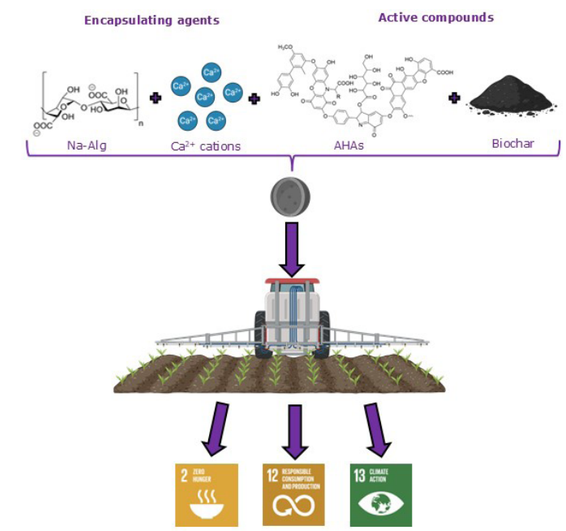
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EUSO - 438 - 0

MULTI-SCALE SPECTRAL MAPPING, RISK ASSESSMENT, AND PHYTOMANAGEMENT INNOVATIONS IN THE EDAPHOS PROJECT

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The EDAPHOS project addresses environmental and socio-economic challenges posed by soil contamination. The project integrates state-of-the-art technologies and ecological practices to rehabilitate polluted soils, foster ecosystem services (ESS), and contribute to sustainable bioeconomic development. The project is structured around three operational pillars:

i) advancing remote sensing techniques to map soil contamination and vegetation health across diverse geographical scales. By integrating satellite imagery, airborne hyperspectral data, and drone-based observations, a comprehensive spectral signature library has been created. This database includes in situ soil and vegetation spectral measurements from seven European case studies (CS). Early results underscore the utility of multi-scale mapping in monitoring NBS effectiveness over time.

ii) applying the TRIAD approach to assess initial soil quality (regarding chemical, ecotoxicological, and ecological indicators) and evaluate improvements achieved through NBS. Advanced analytical methods, such as lab-on-chip technology, have been developed to streamline ecotoxicological testing. Soil composites from Greece and Spain revealed severe pollution, with high levels of As (>750 µg/g), Pb (>9000 µg/g), and Zn (>15000 µg/g). These findings confirm the necessity of targeted NBS interventions. Preliminary enzyme activity measurements showed a decline in key metabolic processes, such as C and N cycling, in highly contaminated soils, reflecting significant ecological stress. Early ecotoxicological assessments, including tests on nematodes and plants, highlighted elevated toxicity levels, particularly in Poland. These metrics provide a robust baseline for monitoring the efficacy of NBS in reducing contamination and restoring soil health over time.

iii) implementing and monitoring NBS, using poplar hybrids as biological model. Other companion species will be tested for their possible hyperaccumulator (e.g., Alliaria petiolata, Brassica juncea, Chrysopogon zizanioides) and nitrogenous fixing (e.g., Lablab purpureus) capacities. Experimental plots in France, Spain, Greece, Italy and Poland tested the efficacy of these co-cropping systems under field conditions. Results showed that some poplar hybrids exhibited high adaptability to contaminated soils on all CS, producing significant biomass while extracting trace elements (TE) such as Cd, Ni and Zn. The use of amendments also showed some effects on biomass production and TE uptake by both woody and herbaceous species. The EDAPHOS project illustrates the potential of NBS in addressing the dual challenges of soil contamination and ESS degradation.

Preliminary results emphasize the synergistic benefits of these approaches, including improved soil health, enhanced ESS, and economic opportunities through biomass

ACKNOWLEDGEMENTS

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EUSO - 442 - 0

MULTI-FACETED BIODIVERSITY INTEGRATION FOR A HEALTHY SOIL AND RESILIENT CROP MANAGEMENT

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The presentation will introduce the project titled "Multi-faceted biodiversity integration for a healthy soil and resilient crop management -SOILRES". SOILRE's mission is to improve soil health and crop resilience in response to the declining health of soil ecosystems, largely caused by the overuse of agrochemicals and the impacts of climate change. This will be achieved by promoting sustainable agricultural practices that prioritise biodiversity and the interactions between soil, plants and microorganisms.

To achieve these goals, SOILRES will adopt a comprehensive strategy that includes active engagement with stakeholders, the development of agroecological methods, and the implementation of digital tools for effective soil health management.

SOILRES will undertake a number of key activities, including the establishment of collaborative co-creation sessions, the development of microbial bioinoculants and biostimulants, and the formulation of best practices tailored to each use case. Field trials will be conducted in six diverse use cases, targeting key agro-climatic regions in Europe (Atlantic (DK), Boreal (FI), Continental (FR), Pannonian (HU) and Mediterranean (IT, PT)), with the objective of validating and refining these interventions.

By assessing agronomic, environmental and cost effectiveness, we will identify challenges and opportunities and design optimal strategies for scaling and replicating sustainable practices.

SOILRES is aligned with the Missions Programme, which is focused on promoting agricultural sustainability and resilience. It is expected that these outcomes will result in a reduction in the dependence on chemical inputs and an increase in crop productivity.

Furthermore, there will be a broader adoption of practices that support biodiversity among farmers. Ultimately, SOILRES aims to strengthen long-term food security and environmental sustainability in Europe by advocating for integrated soil and crop management strategies.



EUSO - 443 - O

RETHINKING SOIL HEALTH IN URBAN SYSTEMS: INSIGHTS FROM RESEARCH TRENDS AND FIELD IMPLEMENTATION

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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With over 65% of the global population expected to reside in urban areas by 2050, the health of urban soils is becoming an increasingly critical, yet often overlooked, component of sustainable city development. Despite their importance for ecosystem services, climate regulation, and human well-being, urban soils remain underrepresented in mainstream soil health research and policy agendas.

This work presents a synthesis of emerging trends and practical approaches for assessing soil health within strictly urban environments. Moving beyond traditional agricultural lands on the peri-urban areas, our focus is on soils embedded within dense cityscapes, where land use complexity, fragmentation, and anthropogenic pressures pose unique challenges. A systematic review of the scientific literature reveals a growing interest in urban soil health, particularly in metropolitan regions with high environmental awareness. However, current research remains uneven in scope: chemical indicators dominate, while biological and physical properties receive limited attention. Similarly, many studies restrict sampling to the top 20 cm of soil, overlooking deeper layers that are critical for understanding belowground processes and long-term soil functioning.

To address these gaps, we propose a standardized, scalable sampling protocol for evaluating soil health in urban systems, designed to capture both spatial heterogeneity and urban-specific stressors. A key innovation is the integration of land fragmentation into the sampling design. Using high-resolution satellite imagery and spatial analysis techniques to assess land fragmentation, urban areas are classified into four fragmentation levels based on edge density of non-sealed patches. This classification guides the selection of 20 representative sampling locations per city, ensuring a balanced coverage of urban landscape structures

The proposed protocol, aligned with the BENCHMARKS framework, enables a comprehensive assessment of biological, chemical, and physical soil health indicators. It includes methodologies for sampling bulk soil, bulk density, meso- and macrofauna (e.g., earthworms), and optional modules addressing plastic contamination and hydraulic properties. Practical guidelines are also provided for sample processing, transport, and storage to facilitate harmonized implementation across diverse urban contexts.

Our findings and tools underscore the urgent need to recalibrate soil health frameworks to better reflect the complexity of urban ecosystems. By bridging the gap between research and practice, and fostering stronger collaboration between scientists, planners, and policymakers, we aim to support a more resilient, informed, and soil-conscious urban future.

ACKNOWLEDGEMENTS

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EUSO - 459 - O

STRENGTHENING SUBSOIL HEALTH THROUGH SUS-SOIL FOR RESILIENT ECOSYSTEMS AND SUSTAINABLE LAND USE

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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According to the European Union's Soil Strategy for 2030, approximately 60–70% of soils across the EU are classified as unhealthy due to a combination of physical (e.g., compaction, erosion), biological (loss of biodiversity, depletion of organic matter), and chemical (salinization, contamination) degradation processes. These issues are further exacerbated by climate change and the extensive use of external inputs in intensive farming systems, undermining soil functionality and the EU's economic resilience.

In response, the EU has set ambitious targets: achieving land degradation neutrality by 2030, restoring degraded ecosystems, ensuring net greenhouse gas removal in the land-use and forestry (LULUCF) sector, and improving water quality by 2027.

While policy and management strategies have traditionally focused on topsoil, the role of subsoils remains largely overlooked. Subsoils supply up to 80% of water and nutrients to plants, store over half of soil carbon, and filter pollutants such as heavy metals and pesticides. Their condition is crucial for sustaining ecosystem services in agriculture, forestry, and urban systems.

The SUS-SOIL project, funded under the EU's Mission Soil, supports these objectives through the establishment of 15 Living Labs that will evaluate Agroecological Subsoil Management (ASM) practices to inform sustainable land-use policy. These Living Labs will first establish an agroecological subsoil management network (ASMN) in Europe and neighboring countries, then create a monitoring strategy to evaluate soil-related ecosystem services in different land uses (agricultural, forest, and urban), and develop models and tools to boost farmers' adoption of ASM practices. The monitoring strategy uses the LUCAS database as the baseline to select data points across Europe under different land use systems. In total, more than 3,000 points will be sampled up to 1m depth.

Soil sampling points are distributed across SUS-SOIL partner regions and were selected based on their consistent land use over the past decade.

Multivariate analysis of LUCAS soil samples in Galicia revealed three principal components explaining 69.14% of the variance. The first component related to pH, the second to organic matter and nitrogen, and the third to cation exchange capacity, phosphorus, and potassium. A negative correlation was found between organic carbon, nitrogen, and pH, reflecting typical dynamics in Galicia's acidic soils, where lower pH levels promote organic matter accumulation by inhibiting microbial activity.

These findings emphasize how different land uses shape soil health indicators, providing valuable insights for promoting agroecological subsoil management.

ACKNOWLEDGEMENTS

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EUSO - 518 - O

NBSOIL ACADEMY: TRAINING SOIL ADVISORS TO PROMOTE SOIL HEALTH ACROSS EUROPE

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Due to the growing concern about soil degradation, the need for qualified people to promote soil conservation is extremely necessary, being essential to create and train new figures of advisors specialised in soils. These professionals would play a key role in promoting sustainable agricultural practices and the conservation of natural resources, especially soil conservation. Therefore, the creation of these specialised learning systems has become a priority to ensure the training of these qualified experts who will face current and future challenges in the most effective way, following the Soil Health Mission in Europe. Based on this need, the NBSOIL (Nature Based Solutions for Soil Management) project arose, which has promoted the incorporation of new information and communication technologies for the training of soil advisors throughout Europe. NBSOIL is a four-year project coordinated by the Institute of Soil Science and Plant Cultivation (IUNG – Poland). Its overall objective is to design an attractive blended learning programme to enable soil advisors to implement a holistic vision of soil health through Nature Based Solutions (NBS) and collaborate effectively across different temporal and spatial scales. The knowledge delivered to soil advisors is built around broad NBS categories: cover crops and intercropping, forest diversification, bioremediation, paludiculture, blue and green infrastructure and biowaste as fertilisers. NBSOIL has been based on a research and innovation action that has co-created an academic prototype based on a 2-year training programme (the NBSOIL Academy) that will provide an immersive, interactive, flexible learning experience, through an introductory massive open online course followed by four advanced modules: 1. Soil and NBS - Identify and recommend multifunctional NBS for soil health, 2. Living Labs facilitation - Facilitate and participate in open innovation spaces, notably the Soil Mission Soil Health Living Labs, 3. Digital tools for soil health monitoring - Make use of digital tools for learning and collaboration and low cost, accurate soil sampling and testing, and 4. Decision-making - Improving soil related decision-making in business and policy. The NBSOIL consortium will deliver impact and contribute decisively to achieve the Soil Health Mission by mainstreaming NBS knowledge and advice for soil management, providing soil health living labs facilitators, making soil monitoring and mapping tech user friendly and inclusive and embedding soil care across all land management and land related decision-making processes. The Academy is a common effort of all the NBSOIL Partners with special contribution of the module and task leaders: CNA, Soil Association, ITAP, IUNG.

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EUSO - 553 - O

DRIVERS OF SOIL HEALTH OF OLIVE GROVES AND THEIR IMPACT ON THE SUSTAINABLE PRODUCTION OF OLIVE OIL IN THE MEDITERRANEAN

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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Land degradation due to historically poor land management has led to unsustainable soil loss in olive cultivation. Yet, the impacts on soil biodiversity and agroecosystem functionality remain primarily unassessed. The Soil Mission project, Soil O-live, conducts a holistic and comprehensive analysis of the soil health status of Mediterranean olive groves on a large scale, enabling comparison among different cultivation methods, varying in intensification, landscape contexts, soil types, and climatic conditions. In addition, we test which variables best explain soil health and key olive production components for each management practice. In this presentation, I summarize the main findings from the initial evaluation of soil health in 52 olive groves across the Mediterranean and their relation to olive productivity.

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EUSO - 575 - 0

SOILWISE: ADVANCING A FAIR DATA AND KNOWLEDGE INFRASTRUCTURE FOR HEALTHIER SOILS IN EUROPE.

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil is a foundational resource for biodiversity, climate resilience, food security, and ecosystem services. Yet, over 60% of European soils are classified as degraded, underscoring the urgent need to reverse this trend through informed decision-making. Achieving this requires evidence-based approaches, which in turn depend on the availability of reliable, interoperable, and actionable data and knowledge to support to support effective policymaking and sustainable soil management (Panagos et al., 2024).

The SoilWise project, funded by the EU Mission Soil, addresses this challenge by developing the SoilWise Repository (SWR), a central access point, FAIR-aligned, and future-ready infrastructure for soil-related data and knowledge. The SWR serves as an open, modular, and scalable platform for harvesting, harmonizing, transforming, and cataloguing soil data and knowledge across Europe. The system will be strategically integrated with the European Soil Observatory (EUSO) and aligned with evolving EU legal and policy frameworks, including the Data Governance Act, Open Data Directive, AI Act, and the upcoming Soil Monitoring Law.

The SWR builds upon established international open standards (e.g., INSPIRE, ISO, DCAT, GloSIS) and leverages cutting-edge technologies , including Artificial Intelligence, semantic web principles, knowledge graphs, and large language models . This enables persistent identification, smart interlinking, and intelligent discovery of soil resources. It captures structured data and explicit knowledge from within and beyond European research and innovation (R&I) projects, especially those aligned with Mission Soil priorities, making them accessible through an user friendly metadata catalogue (Řezník et al, 2024).

Crucially, SWR is built through co-design, co-creation and co-validation with a diverse stakeholder community: land managers, researchers, public authorities, businesses, agri-tech developers, and policymakers. Practically, efforts are being made on stakeholders interactions, to ensure that SWR matches the different communities' needs. As of February 2025, the second SWR prototype illustrates the potential of AI-enhanced search, FAIR-compliant workflows, and stakeholder-centric design to significantly enhance the visibility, accessibility, and reuse of soil intelligence. This contribution will share early results, outline the roadmap towards the integration with EUSO , and demonstrate how SoilWise is helping to realize the ambitions of the Mission Soil, enabling healthier soils, more informed decisions, and a sustainable future for Europe.

ACKNOWLEDGEMENTS

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EUSO - 585 - 0

DEVELOPING A BARE SOIL COMPOSITE TO IMPROVE SOIL ORGANIC CARBON MAPPING IN DENMARK

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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Soil organic carbon (SOC) is a key indicator of soil health, influencing soil structure, nutrient retention, water-holding capacity, and climate regulations. Accurate, high-resolution data on SOC is essential for greenhouse gas accounting and the implementation of sustainable agricultural practices.

Remote sensing plays a growing role in digital soil mapping, as soil interacts distinctly with electromagnetic energy. However, vegetation and crop residues often obscure soil reflectance, limiting the effectiveness of satellite images for SOC estimation. To address this, recent methods extract bare soil pixels from multispectral satellite imagery over time, generating bare soil composites (BSCs) - synthetic, vegetation-free images that enhance spatial soil modeling.

These BSCs have proven effective for large-scale, unbiased prediction of soil properties, including SOC. We hypothesized that the use of a BSC developed for Danish conditions improves the accuracy of large-scale SOC predictions in comparison to a pan-European BSC.

In this study, we developed a Denmark-specific BSC by combining optical (Sentinel-2) and radar (Sentinel-1) satellite data. We used images captured during the wet season (September–March) from 2018 to 2025. Bare soil reflectance values were extracted from Sentinel-2 bands, excluding pixels with urban areas, water bodies, clouds, shadows, and snow. The Normalized Difference Vegetation Index (NDVI) and Normalized Burn Ratio (NBR2) indices were applied to filter out photosynthetically active and non-active vegetation. Sentinel-1 pixels were labeled as bare soil if they matched bare soil pixels in a Sentinel-2 image recorded within the previous 8 days. Production of the Denmark BSC was accomplished using the Planet Insights Platform and the associated open-source Python packages eo-learn & eo-grow.

We compared the performance of SOC prediction models using our Danish BSC against the SoilSuite product, which is a pan-European database of spectral and statistical properties of bare soils.

Our findings demonstrate that a regionally adapted BSC significantly improves SOC prediction at the national scale compared to pan-European composites. Integrating optical and radar data enhances the robustness of bare soil detection, particularly under conditions of frequent cloud cover or limited optical data availability.

This approach provides a scalable and transferable framework for other regions seeking to enhance SOC monitoring. As soil health assessment becomes a global priority, tools like these will be essential for informed land management and policy development.

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EUSO - 611 - 0

FROM PILOTS CASES TO POLICIES: THE HUMUS PROJECT EXPERIENCE IN PARTICIPATORY SOIL GOVERNANCE

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The Horizon Europe project HuMUS contributes to the EU Mission “A Soil Deal for Europe” by empowering local and regional authorities to co-create governance models that foster soil health. With a network of 34 pilot cases across Europe, HuMUS proposes a participatory approach to multidisciplinary soil governance, addressing environmental, social and institutional challenges in each territory.

At the heart of the project lies the concept of the Territorial Management Agreement (TMA) - a co-designed tool enabling cross-sector collaboration among public institutions, civil society, academia and industry.

TMAs aim to establish locally grounded and long-term commitments for soil regeneration, land-use planning, and sustainable soil management.

This oral presentation describes HuMUS’ conceptual framework and implementation strategy, focusing on two key dimensions:

- Initiation and co-design of TMAs - the HuMUS methodology

- The supportive role of public entities, and how intermediate authorities can foster enabling environments through policy alignment, technical guidance, and institutional facilitation.

By highlighting real-world lessons from diverse European contexts within the project, the session will provide insights for researchers, policy-makers, and practitioners engaged in soil-related planning and policy.

It will also contribute to broader reflections on how to operationalise the Mission Soil objectives through inclusive, adaptable, and scalable governance models.

ACKNOWLEDGEMENTS

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HuMUS
Healthy Municipal Soils

EUSO - 746 - 0

SOLACE PROJECT: UNDERSTANDING THE LINKS BETWEEN SOIL POLLUTION AND CANCER IN EUROPE.

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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Soil pollution is a significant environmental and health concern in Europe, with potential links to cancer incidence. The Exploratory Research project “Understanding the links between SOil pollution and CancEr” (SOLACE)” aimed to investigate the complex relationships between soil properties, pollution, land use and human health, providing a foundation for further research and policy development, as part of the Joint Research Centre’s (JRC) strategic scientific development. The scoping review of the existing studies linking soil pollution and cancer identified the knowledge gaps in the fields. We present a framework encompassing four key objectives that contribute to the strategic scientific development of the Joint Research Centre (JRC) and support various environmental health initiatives: 1) Scientific contribution from the SOLACE project to the knowledge of soil pollution in EU soils, 2) analysis of the associations between soil pollution and cancer outcomes. 3) Enhancing the Zero Pollution Action Plan Clean Soil Outlook, and 4) Revising the Sewage Sludge Directive for assessing the impact of sludge application on accumulation of metal(loid)s in agricultural soils.

The SOLACE project has made significant contributions to our understanding of soil pollution and its impact on human health (Yunta Mezquita et al., 2025). The project’s findings have shed light on the complex relationships between soil properties, soil pollution, land use, and human health, and have provided a foundation for future research and policy-making. Statistical analyses of pollution indices shed light on soil properties influencing heavy metal contamination, with alkaline soils, loam textures, and higher soil organic carbon (SOC) showing a greater propensity for contamination. Agricultura.

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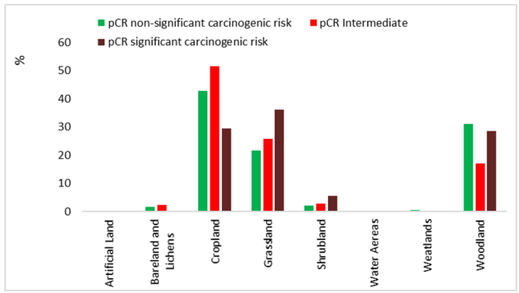


Figure 1. Distribution (percentage) of each of the three Carcinogenic Risk (CR) categories across different land cover classes



EUSO - 829 - O

CHALLENGES OF SOIL MONITORING AT LIVING LABS ON PERMANENT CROPS

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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The Living Labs (LL) concept dates back the 2000's some having both a social and a physical dimension where it is possible to individuate objectives, perform research, test solutions, and exchange knowledge following a co-creation and multi-actor approach. The co-creation process should start early, be continuous, and include all the relevant actors, who will closely collaborate in identifying the problems and developing and implementing solutions (Bentzen, 2022). LivingSocial is a project addressing soil health on permanent crops (vineyards, olive and chestnut groves and, apple and hazelnut orchards), through the implementation of 50 experimental sites at 5 LL [Luso-Galician (North of Portugal-North of Spain), Andalusian (South of Spain), Loire Valley and Beaujolais (France), North-Western Italy – Piemonte and Grojéc (Poland)], and it brought several challenges, to all the actors, from the academia to the farmers.

Soil scientists need to be prepared to deal with and to communicate the limitations of tacit knowledge, uncontrollable variables (e.g., type of soil, unpredictable climatic events, unexpected crop diseases), and the difficulties or even the impossibility of replication. They also need to be available to build up the sampling designs and soil monitoring framework with the farmers, to integrate their perception and expectations, the relevance of the evaluations and solutions to be tested, and the possible transfer of methodologies for a long-term evaluation of soil health changes. Meanwhile, additional difficulties are brought by the standardization and harmonization of methods and procedures. Standard procedures or recommended soil monitoring protocols may, in fact, not be directly transferable to all real-life settings and to intensively managed soils. All these difficulties require continuous reflection and adjustment and must be transparently shared and discussed with all the stakeholders, as this could jeopardize bigger objectives such as transferring solutions to other regions. The aim of this presentation is thus to share the challenges faced, to promote discussion, and collaboratively find solutions. The experimentation under real-life conditions is a highly valuable learning process for everyone involved in LLs, as it truly enables the generation of significant knowledge on new management practices aimed at healthier soils, thus justifying all the efforts on its refinement, but also on the management of expectations.

ACKNOWLEDGEMENTS

The LivingSoiLL "Healthy Soil to Permanent Crops Living Labs", is a Horizon Europe project that is funded by the European Commission under the Grant Agreement 101157502 within the framework of the EU Mission 'A Soil Deal for Europe'.

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EUSO - 331 - P

SPATIAL CHARACTERIZATION OF AGGREGATE STABILITY IN AN OXISOL UNDER NO-TILL SYSTEM IN THE BRAZILIAN CERRADO

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Geostatistical analysis serves to minimize costs and environmental impacts in the field, allowing different management practices to be applied within the same area and only where necessary. The variability of soil attributes can indicate the types of management to be adopted, as it estimates the spatial dependence of each attribute and the extent to which it influences the soil. The objective of this study was to analyze the variability of aggregate stability in an Oxisol under a No-Till System (NTS) in the Brazilian Cerrado, aiming to identify the main factors influencing this variability and their implications for soil physical quality and sustainability in tropical agricultural systems.

Samples were collected at 60 points, spaced 10 meters apart, at two depths (0.00–0.20 m (1) and 0.20–0.40 m (2)). The attributes that exhibited spatial dependence were: geometric mean diameter (GMD1 and GMD2), mean weight diameter (MWD1 and MWD2), clay (CLY1), and silt (SLT1), ranging from moderate to strong. Using interpolation of the collected data, maps were generated using the kriging method. The highest spatial determination coefficient (r^2) for the adjusted semivariogram parameters was SLT1 (0.968), and the lowest was MWD2 (0.799). The geostatistical ranges obtained varied between 15.2 m (MWD1) and 53 m (SLT1).

The analysis yielded good results for both GMD and MWD, indicating that the soil is well-structured—meaning the No-Till System (NTS) has a direct relationship with soil aggregate stability, further highlighting the role of organic matter as its primary binding agent.

ACKNOWLEDGEMENTS

APOIO: Trabalho realizado com apoio da (CAPES) - Código de Financiamento 001.

Descriptive Analysis of the Physical Attributes of a Latossolo (Oxisol) Under No-Tillage System (NTS).



EUSO - 347 - P

TOWARDS A EUROPEAN SOIL LITERACY PORTAL

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 16. CONNECTING PEOPLE AND SOILS

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The EU funded SOILSCAPE project is an innovative initiative that seeks to harness the power of cultural and creative activities, artists, and civil society organizations to promote soil preservation across Europe and beyond. Coordinated by AFES and involving 18 partners from 10 countries, SOILSCAPE aims to revolutionize our relationship with soil through artistic practices, education and participatory approaches. By integrating expertise from soil science, the arts, humanities, and decision-making, the project aspires to foster a deeper understanding and appreciation of soils.

A central component of the SOILSCAPE project is the creation of a Soil Literacy Portal, built in cooperation with the European Commission's Joint Research Center (JRC), in line with the EU Soil Strategy 2030 and the existing EU Soil Observatory. This interactive, multilingual and accessible portal will be designed to educate, engage, and empower users to understand and take action for soil health and sustainability. We believe that art can play a crucial role in raising awareness, fostering emotional connections, and inspiring action for soil preservation.

Soil literacy aims to empower society. It is not just a matter of acquiring information but of integrating that knowledge into everyday discourse and policy. By framing soil as dynamic and interconnected with social and ecological systems, it offers a more holistic path to fostering sustainable soil engagement. Soil knowledge is about what you know, while soil literacy is about how you use that knowledge in real-world contexts.

The portal will be a cornerstone in the project's strategy to promote soil literacy through innovative communication and education methods tailored to local contexts. The idea is to collaborate with the JRC and other Mission Soil projects to feed the portal with educational resources and knowledge hub, data & mapping tools, best practices, solutions & art for soil awareness, community engagement & networking, policy and advocacy tools and gamification, challenges & interactive art.

The SOILSCAPE project is now on the brink of building on eight European soil and art networks to whom the portal will serve as a practical tool. By 2028, SOILSCAPE aims to extend its actions to 30 regions, significantly broadening its impact. The Soil Literacy Portal will play a crucial role in this expansion, facilitating the dissemination of knowledge and best practices. Through national festivals dedicated to soil in eight countries and the development of international partnerships with the help of UNESCO as partner, SOILSCAPE seeks to embed a culture of artistic intelligence about soil within the broader public consciousness.

ACKNOWLEDGEMENTS

We would like to thank:

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- the members of the AFES SOILSCAPE working group

EUSO - 385 - P

A MULTI-SCALE, MULTI-SOURCE APPROACH TO LAND DEGRADATION ASSESSMENT IN SEMI-ARID CEREAL SYSTEMS: INSIGHTS FROM WESTERN MESAORIA, CYPRUS

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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Land degradation in semi-arid agricultural systems poses a critical threat to crop production. Therefore, conducting reliable land degradation assessments at the field scale is important for identifying degradation patterns and supporting sustainable land management practices. In regions where land is divided into small parcels and diverse management practices are applied, field-level assessments becomes especially challenging, particularly when remote sensing datasets lack the spatial resolution to capture parcel-specific conditions. This study aims to develop an integrated, multi-source, multi-scale framework to assess land degradation at the field level in cropping systems dominated by rainfed cereals. The research is conducted in the Morphou Community Complex, located in the western Mesaoria plain of Cyprus, an area with extensive rainfed cereal cultivation. The methodology combines field-based assessments, crop cultivation records, land manager input and satellite observations. Field data collection followed the WOCAT Questionnaire for Mapping Land Degradation and Sustainable Land Management (QM). Crop cultivation records were obtained from the Single Area Payment Scheme applications funded by the EU Rural Development Program. Satellite data were used alongside and compared with degradation indicators from Trends.Earth software. Additional insights into land management practices were collected through systematic interviews. Land condition was assessed at selected sites using both present-day observations and historical information. Preliminary findings and data integration indicate that this multi-source and multi-scale approach enhances the spatiotemporal resolution of land degradation assessment. Field surveys, historical datasets, and satellite imagery, combined with grower insights, reveal variation in land conditions related to management practices, land characteristics, and exposure to climatic factors. Fields under continuous cereal cultivation with limited conservation practices are expected to demonstrate greater susceptibility to degradation than those implementing sustainable land management. The integration of diverse datasets offers a comprehensive understanding of the processes accelerating land degradation or preventing land restoration, along with their underlying drivers. This approach demonstrates the value of multi-source data to support the development of targeted sustainable land management strategies, contributing to regional and national efforts to achieve Land Degradation Neutrality (UN SDG 15.3.1) and to safeguard long-term food security in rainfed cropping systems. Research approaches will be exchanged with the Desertification Communities of Practice and Knowledge, hosted by the EU Mission Soil TERRASAFE and MONALISA projects.

ACKNOWLEDGEMENTS

This research is financially supported by the TERRASAFE project, co-funded by the European Union (GA 10115737) and UK Research and Innovation.



Drought-affected rainfed cereal croplands in the Mesaoria plain of Cyprus



EUSO - 410 - P

ASSESSING SOIL DEGRADATION IN EUROPE AT PARCEL LEVEL: A METHODOLOGICAL APPROACH USING LUCAS AND IACS DATA

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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We will introduce the Soil Degradation Calculator as a valuable tool for assessing the environmental impact of agricultural practices (i.e. crops and farming systems) on soil degradation. Land Use/Cover Area frame Survey (LUCAS) data offers a robust and standardized framework for monitoring land use and land cover changes, while the Integrated Administration and Control System (Wojda et al. 2023) (IACS) data provides detailed information on agricultural parcels and practices. Combining both datasets has the potential to support the development of effective policies and strategies to mitigate soil degradation and promote sustainable agriculture in Europe. The methodological approach of the Soil Degradation Calculator follows two steps:

Step 1: Provide scientific and consolidated approach to assess, in quantitative way, the amount of degraded soils (in hectares) in Europe by using the soil degradation dashboard (https://esdac.jrc.ec.europa.eu/esdacviewer/euso-dashboard) developed by the European Soil Observatory (EUSO). Currently, the EUSO dashboard is based on 19 soil degradation indicators (Panos et al. 2024). For this work, 17 soil indicators were associated with specific soil degradation processes, which were assigned a cumulative percentage value. The weighting factor was equally calculated for each soil degradation process (5.8%), indicating that each degradation process contributed equally to the overall soil degradation, but this weighting factor can be adjusted ad hoc in accordance with the local or policy requirements. The soil indicators were grouped into five classes of degraded soil, with each class representing a range of cumulative percentage values.

Step 2: Raster maps for each of the soil degradation processes from the step 1 were merged with the IACS data at parcel level to extract the soil degradation information for each parcel and also the area (ha) for each of the soil degradation categories. For this analysis in this case study, we used two different regions; France and Castilla y León (Spain).

The methodological approach was used to quantify the soil degradation in Castilla y Leon when assessing agricultural parcels with wheat. For this case study 556,764 agricultural parcels cultivated with wheat were analyzed. The data also shows that most of the degraded land in these provinces is classified as low degradation. Burgos has the highest proportion of low degradation at 85%. Soria and Zamora also have high proportions of low degradation, at 89% and 90%, respectively.

The Soil Degradation Calculator proves to be useful for informing policy decisions related to land degradation and sustainable agriculture at the European level. By combining both LUCAS and IACS datasets, the Soil Degradation Calculator can estimate the environmental footprint of different crops and farming systems on soils, enabling policymakers and stakeholders to make informed decisions about sustainable agriculture and land use practices.

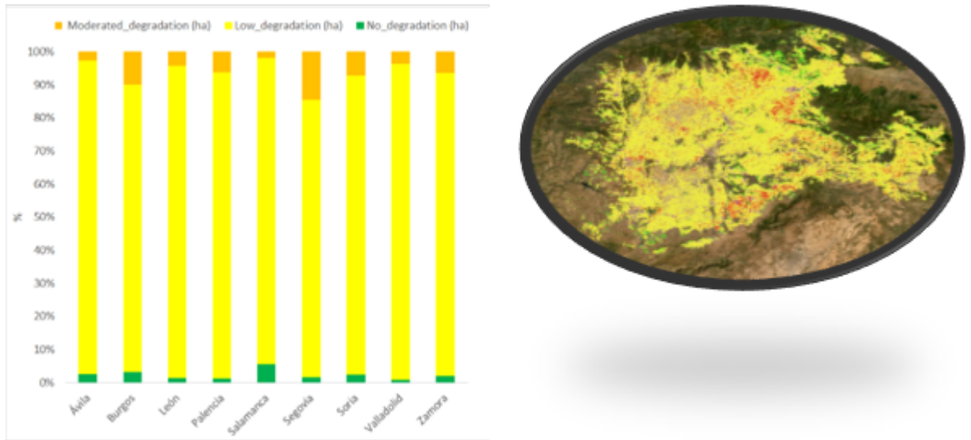


Figure 1. Distribution of soil degradation classes in the regions of Castilla y León

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EUSO - 416 - P

ADDRESSING POINT SOURCE SOIL POLLUTION IN THE WESTERN BALKANS: CHALLENGES AND OPPORTUNITIES FOR EU INTEGRATION

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil pollution poses a significant threat to human health and the environment in the Western Balkans, contaminating food and water sources with potentially toxic elements (PTE) and degrading ecosystems by reducing soil functions and biodiversity (Arias-Navarro et al. 2024a). Industrialisation over the past century has made soil pollution a widespread issue in the region.

This study aims to summarise the status of point source soil pollution, identify knowledge gaps, and support the implementation of the Green Agenda for the Western Balkans, with a focus on soil remediation priorities (Belis et al., 2024). Through the analysis of 118 contaminated or potentially contaminated sites (Fig. 1), the study reveals that industrial and mining activities are the primary sources of soil pollution, while asbestos and nuclear energy contribute relatively less (Arias-Navarro et al. 2024b). Despite some progress in waste management, inadequate systems remain a major pollution source. Countries such as Serbia and North Macedonia have conducted preliminary assessments, but comprehensive regional data is lacking. Challenges include weak legal frameworks, insufficient funding, and limited site investigations. Effective strategies must prioritise high-risk sites and establish clear criteria for identifying pollution hot-spots. A registry of contaminated sites is essential, starting with the most critical areas and expanding to include all sites with health and environmental risks. Public awareness and remediation efforts remain limited, underscoring the need for integrated policies, increased funding, and community engagement.

Immediate action is crucial to mitigate soil pollution and protect public health. This work emphasises the urgent need for coordinated soil protection strategies to ensure sustainable land use and healthy soils in the Western Balkans.

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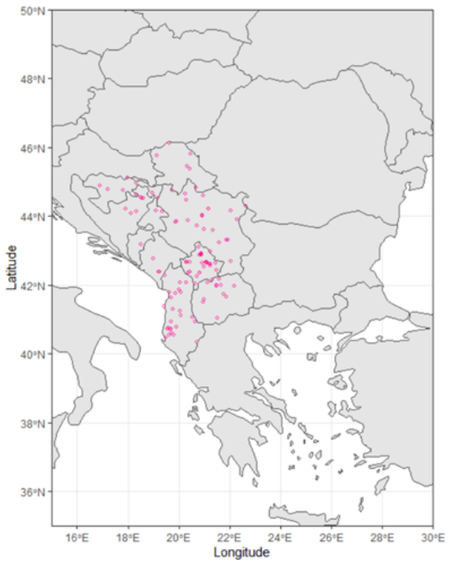


Figure 1. Location of the contaminated sites in the national inventories

EUSO - 417 - P

LUCAS TOPSOIL 2015 SURVEY FOR THE WESTERN BALKANS: PRESENTATION OF THE DATASET AND RESULTS

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The European Union has prioritized soil health, highlighted by the Soil Mission “Soil Deal for Europe” under Horizon Europe, aiming to enhance soil quality by establishing 100 Living Labs and Lighthouses by 2030. The Soil Monitoring and Resilience Law underscores this effort, targeting a reduction in unhealthy soils, currently estimated at 60-70%. The Western Balkans face similar pressures but suffer from a lack of comprehensive soil health data, complicating targeted interventions (Belis et al., 2024). This study addresses this gap, utilizing data from the LUCAS WB 2015 Topsoil Survey across Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia. The survey’s 1,015 soil samples provide a critical dataset, characterizing soil health and variability in the region.

The LUCAS Soil Module (Orgiazzi et al. 2018) is unique in its harmonized and regular data collection efforts across the EU, vital for aligning Western Balkan countries with European standards, especially under the auspices of the EU enlargement policy promoted by the Von der Leyen Commission. The survey highlights the diverse soil types in the region - from Serbia’s fertile Chernozems to Albania’s challenging saline and sodic soils, offering insights into the spatial variability of soil properties relative to land cover types and climatic zones (Fig. 1). Detailed laboratory analysis reveals significant differences in soil attributes across climatic regions and land use types, providing a nuanced understanding of the pressures facing these soils.

This work outlines how the comprehensive soil dataset can inform soil research, policy, and management, bridging existing data gaps and fostering evidence-based decision-making. Moreover, it emphasizes the implications for sustainable soil management, assisting the region in conforming to the EU Soil Strategy 2030, aiming for healthy soils by 2050. By presenting a detailed description of the LUCAS database, the study underscores its relevance to stakeholders interested in soil conservation, policy formulation, and agricultural productivity.

In conclusion, the integration of soil health data from the Western Balkans into broader European soil health initiatives provides a unique opportunity to pave the way for improvements in soil management across the region. This study represents a pivotal step towards achieving healthier soils in the Western Balkans, contributing to the EU’s overarching goal of widespread soil health by 2050. Future research will capitalize on this dataset to further explore soil-related challenges and inform policy measures that prioritize soil sustainability and resilience in the face of mounting environmental pressures.

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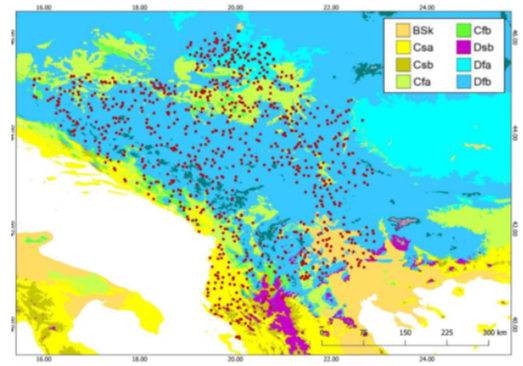


Figure 1. Distribution of LUCAS points in the Western Balkan region within climatic zones



EUSO - 499 - P

A BOTTOM-UP FARMER-RESEARCHER APPROACH: ADVANCING SOIL HEALTH THOUGH PARTICIPATORY

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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Sustainable soil management is essential to keep agricultural soils healthy. In recent years, the EU-supported project (Interreg) has led to the advancement of agroforestry, regenerative agriculture, agroecology, and precision agriculture. However, the distribution of best practices remains fragmented, limiting their regional or global influence. The goal of Soi4Nature is to understand the characteristics of soil and the many management techniques that influence soil health. Additionally, to support regenerative agriculture to improve the productivity and health of soils in the Pannonian region while also conserving the environment and local soils. Various farming approaches will be gathered, tested, and distributed to improve the soil and ecological functions of the agricultural land in the research region. The proposed research, Soil4Nature, aims to address interconnected soil and farming issues through a comprehensive approach. This research will collect, harmonize, analyze, and integrate data from real-world experiments. It will also facilitate collaboration among farmers, agricultural technology experts, and socio-economic research centers in Hungary and Slovakia to promote sustainable soil and farm management practices. In its final stage, Soil4Nature will develop methodologies for upscaling and disseminating its findings effectively. The study will culminate in creating an interactive digital farm dashboard, enabling visual and user-friendly communication of results to non-technical users.

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Sustainable agriculture, reduced tillage, Soil management, Adoption practices, and Conservation agriculture.

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Abstract.pdf

EUSO - 584 - P

FINE-RESOLUTION MAPPING OF VIS-NIRS DATA SUPPORTS THE SOIL HEALTH ASSESSMENT IN DENMARK

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Accurate, high-resolution soil data are essential for advancing soil science and informing decisions on sustainable land use and soil health. Visible near-infrared spectroscopy (vis-NIRS) offers rapid soil analysis and cost-effective estimates of soil properties and identification of patterns linked to soil-forming processes.

In the soil mapping context, vis-NIRS data have been used as an input to produce environmental layers to predict soil properties and classes. This study explores how vis-NIRS data can be used to generate spatial information that supports national soil mapping and soil health assessment in Denmark. We aimed to: i) Create 10-m resolution maps of latent variables extracted from vis-NIRS data using dimensionality reduction techniques, ii) Test the performance of these latent variables in predicting soil organic carbon content (SOC) and pH in calcium chloride, and iii) Define spectrally homogeneous soil zones across Denmark.

A total of 7,009 vis-NIRS (measured on 2-mm sieved air-dried soil samples with a FOSS-DS2500 vis–NIR spectrometer) were compressed into latent variables using principal component analysis, kernel principal component analysis, and autoencoders. These latent variables were mapped using XGBoost models trained with 43 harmonized environmental layers (climate, terrain, geology). We used a non-parametric bootstrap approach to estimate the 10% and 90% quantiles to calculate the 80% prediction interval as an uncertainty measure of our predictions.

The latent variable maps were used with land use, vegetation indices, and groundwater data to model pH and SOC. For pH, the use of environmental layers and latent variables improved the performance across all methods. For SOC, the combination of autoencoder variables and environmental layers achieved the highest accuracy (R2cv=0.35, RMSEcv=1.8%), in contrast to the use of only latent variables from PCA (R2cv=0.25, RMSEcv=1.5%), KPCA (R2cv=0.23, RMSEcv=1.5%), and AE (R2cv=0.24, RMSEcv=1.6%).

We also clustered the latent variable maps to define spectrally homogeneous zones, which mirrored the predominant pedogenetic conditions across Denmark. Further, the spectral zones also revealed patterns associated with vegetation and land use history.

This study demonstrates that spatialized vis-NIRS data can support fine-scale digital soil mapping and improve the prediction of soil health indicators. These products can help define soil zones and provide a foundation for future soil health monitoring efforts in Denmark.

ACKNOWLEDGEMENTS

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EUSO - 914 - P

OPTIMISING PORTABLE VIS–NIR SOIL SENSING: A LUCAS-BASED EVALUATION OF SPECTRAL SUBSETS AND MACHINE LEARNING MODELS

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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Soil spectroscopy offers a rapid, non-destructive route to soil-property assessment, yet bridging the gap between laboratory spectrometers and practical in-field sensing remains a key challenge. Here, we use the pan-European LUCAS VIS–NIR dataset (400–2500 nm) to conduct a purely theoretical screening of restricted wavelength windows that mimic twelve commercially available portable spectrometers. Four machine-learning algorithms—support-vector regression, Cubist, random forest, and multi-layer perceptron (MLP)—were benchmarked against ordinary least-squares regression for predicting thirteen soil properties.

Spectral subsets of 1000–2500 nm and 1350–2500 nm, corresponding to the nominal coverage of Trinamix and NeoSpectra devices, achieved prediction accuracies comparable to those from the full spectral range. In contrast, subsets confined to 350–1000 nm performed poorly. Feature-importance analysis confirmed that wavelengths above ≈1750 nm contain the most diagnostic information. Across all subsets, MLP delivered the highest R^2 values—exceeding 0.80 for organic carbon, total nitrogen, pH, and clay—whereas potassium, phosphorus, and coarse fragments remained difficult to predict ($R^2 < 0.30$).

These results highlight 1000–2500 nm as the critical region for future low-cost soil sensors and underline MLP as a robust modelling choice. While the study is confined to simulated sensor bands, it provides clear guidance for hardware design and deployment strategies; verification with real Trinamix and NeoSpectra units—on both dried and in-situ samples—constitutes an essential next step.

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EUSO - 936 - P

UNLOCKING SOIL DATA FOR POLICY, ACTION AND INNOVATION

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The EU Soil Monitoring Law marks a pivotal step in safeguarding soil health, but fragmented and underused data threaten its implementation. This poster presents SoilHive, an open, interoperable platform developed by the Varda Foundation to integrate and harmonize soil data across public, private, and research sources. With 400,000+ geolocated data points, 60+ harmonized parameters, and API-accessible services, SoilHive supports national and european initiatives, as well as global innovation challenges.

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EUSO - 1059 - P

SOIL CARE: LINKING SOIL HEALTH AND MANAGEMENT PRACTICES AT SPATIAL SCALE

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The European Commission has set an ambitious objective of achieving healthy soils across Europe by 2050 and is developing several policies to support this goal. Although significant resources are being invested in research to understand how chemical, physical, and biological factors explain soil health from local to pan-European scales, the links between soil health and soil management practices at spatial scale remains underexplored. Understanding how soil management practices affect soil health across different pedoclimatic conditions can guide stakeholders and enable continuous monitoring. This study aimed to explore the relationship between soil management practices and selected soil health indicators in agricultural fields in Denmark. To achieve this, we collated spatial data from government agencies related to farming activities, representing soil management activities ("Soil Care") at the field level. Specifically, we gathered information on type and amount of fertilization (chemical x manure), cover crops, cropping systems (grass rotations), organic farming, and tillage intensity (remote sensing) across Denmark. For soil health assessment, we selected key indicators including soil organic carbon (SOC), nitrogen, soil pH and electrical conductivity, measured at 0–30 cm soil depth. We analysed the data within homogeneous soil regions, referred to as soil monitoring units, which are based on soil type and landscape position. Overall, we found that manure application, crop-grass rotation and organic agriculture were positively correlated with increases in SOC and nitrogen. These findings can support spatial monitoring of best management practices for improving soil health. The use of remote sensing technology enables efficient and widespread monitoring, making it feasible to integrate Soil Care into the Common Agricultural Policy (CAP) system. Although comprehensive soil monitoring can be challenging and time-consuming, identifying and monitoring soil management practices can accelerate progress toward healthy soils by 2050.

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EUSO - 1099 - P

A CONTINENTAL-SCALE SOIL SPECTRAL LIBRARY FOR LINKING SPECTROSCOPY TO BELOWGROUND BIODIVERSITY MONITORING

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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The quantification of soil biodiversity remains a major challenge in environmental monitoring, particularly due to the absence of scalable, harmonized approaches applicable across diverse ecosystems. While visible–near-infrared–shortwave infrared (Vis–NIR–SWIR) spectroscopy has been extensively applied for predicting soil physicochemical properties, its potential for inferring biological indicators remains largely unexplored, owing in part to the lack of standardized biodiversity-linked spectral datasets.

To address this, we established a continental-scale Soil Spectral Library comprising over 400 soil samples collected from 12 European countries, covering major pedoclimatic zones and land-use types. Each sample was spectroscopically measured in the 350–2500 nm range (Vis–NIR–SWIR), following the methodological guidelines defined in the "IEEE P4005 Standards and Protocols for Soil Spectroscopy". The spectral data are linked to a set of reference measurements, including physicochemical parameters and biodiversity indicators derived from molecular, morphological, and functional assessments of soil biota (e.g., earthworms, Collembola, Acari, nematodes, and microbial communities).

Given the established links between soil physicochemical properties and belowground biodiversity, Vis–NIR–SWIR spectroscopy offers a promising indirect pathway for biodiversity assessment. Spectral reflectance captures key information related to organic matter content, mineral composition, moisture, and texture, all of which influence the abundance and community structure of soil organisms. Building upon these correlations, spectral data can be used to infer biological properties through statistical or machine learning models, offering a scalable, rapid, and non-destructive tool for biodiversity monitoring. Identifying the spectral regions most predictive of biodiversity indicators could further support the development of generalized models applicable across ecosystems and soil types.

ACKNOWLEDGEMENTS

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EUSO - 1135 P

A SOIL ENZYMATIC ACTIVITY READER TO ASSES SOIL ORGANIC NITROGEN MINERALIZATION

· EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM / GT 09. SOIL HEALTH

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Biological soil parameters are essential for understanding soil processes and functionality, as biological activity drives nutrient cycling and organic matter decomposition. Yet, biological parameters are underrepresented in soil health assessments compared to chemical and physical indicators. Soil extracellular enzymatic activities (EEA) are particularly useful as biological indicators, as the activity of enzymes leads to nutrient release and because they reveal soil's biological responses to external factors like fertilization, management practices, or climate shifts. However, a link between EEA, nutrient mineralization rates, and other soil properties is needed to correctly interpret the data.

Material and Method:

Here we introduce the Soil Enzymatic Activity Reader (SEAR, Figure 1). A device to measure the activity of 5 extracellular soil enzymes in parallel, laboratory independent, and on-site [1]. To connect the dots between nitrogen mineralization and enzymatic activity, we set up an incubation experiment with 187 soil samples, collected in Switzerland, France, and Germany (Figure 2) in 2025. These samples were incubated at room temperature in triplicates for 56 days in the laboratory with measurements of mineral nitrogen and enzymatic activities at the start and the end of the incubation period to obtain nitrogen mineralization rates. 24 out of the 187 samples were duplicates that were buried for the same period in a grassland soil to bridge the laboratory incubation results to field incubation results.

ACKNOWLEDGEMENTS

Results:

The used soils cover a wide range of soil properties and originate mainly from agricultural areas. Preliminary results show a positive correlation between the measured activity of β-Glucosidase (GLS) and β-glucosaminidase (GLA) at the beginning of the experiment with the mineralized nitrogen rates. Results for the use of EEA in the context of soil mineralisation predictors and dynamic soil health indicators will be discussed, also in the context of existing scientific results [2].

Conclusion:

The possibility to measure soil extracellular enzymatic activities fast, easy, standardized, and on-site enables its usage as a biological soil health indicator that – as indicated with this study - can be used to estimate nutrient mineralization and nutrient cycling. These insights can be used to improve fertilization planning, model nutrient losses and monitor effects on the soil microbiome due to management changes, which are important steps to reduce the environmental impact of agricultural practices.

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GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 01 - 6 - O

ANTHROSOLS REVISITED

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 09. SOIL HEALTH

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The classification of Anthrosols in the latest edition of the World Reference Base for soil resources was reviewed during an updating exercise of more than a thousand soil monoliths present in the collection of 'ISRC World Soils', and the one at the KU Leuven. Relative few Anthrosols were present in these collections, but they revealed inconsistencies in classification criteria used since the introduction of these soils in the FAO/UNESCO Revised Legend to accommodate soils that are strongly influenced by agricultural practices. A historical overview is given of these criteria and their definitions. Recommendations are made for an expansion in monolith collections focusing on these soils that are too often neglected in traditional soil surveys. A number of proposals are made to improve the classification.

KEY WORDS:

Anthrosols, World Reference Base for soil resources (WRB), soil classification.

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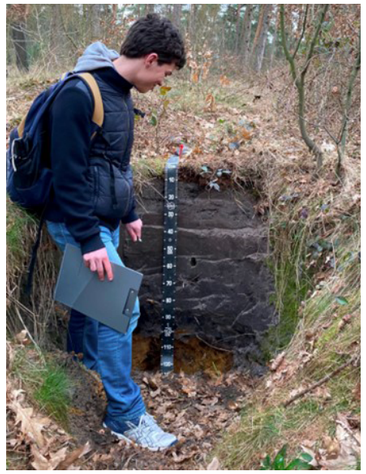
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Plaggic Anthrosol near Hamont-Achel, Belgium. Pic@Vancampenhout, K., 2023

GT 01 - 28 - O

SIGNATURE AND FRACTIONATION OF RARE EARTH ELEMENTS IN SOIL CARBONATE NODULES ALONG A CHRONOSEQUENCE IN TAIWAN

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Rare earth elements (REEs) have been detected in soil carbonate nodules (Alfaro et al., 2018), where their redistribution patterns can offer valuable insights into pedogenesis over time scales. This study aimed to characterize the signature and fractionation of REEs in carbonate nodules of aged-alluvial soils along a chronosequence in the sub-humid coastal plain of southwestern Taiwan. Four Alfisol pedons containing carbonate nodules were sampled for this study. The soil ages, estimated on the basis of phases of shoreline transgression and regression, were 10,000 BP (Before Present), 8000 BP, 5000 BP, and 3000 BP; corresponding pedons were designated as KS1, KS2, KS3, and KS4, respectively. The nodules predominantly comprised of calcite with minor amounts of quartz, chlorite, and illite. REE concentrations were lower in the nodules than in the bulk soils (12.7-108 v.s. 132-315 mg·kg-1). The upper continental crust normalized distribution patterns of REEs in the nodules differed from those of REEs in corresponding bulk soils (Wu et al., 2024). Lower (La/Sm)N and (La/Yb)N ratios indicated higher levels of heavy REEs in the nodules than in the bulk soils, implying that REEs fractionation occurred within the nodules during progressive pedogenesis. Although no consistent trends in the REEs fractionation indices were observed in the bulk soils, the (Gd/Yb)N ratio in the nodules markedly decreased with decreasing soil age across the chronosequence. Thus, heavy REEs and the (Gd/Yb)N ratio in the nodules emerged as key REEs signatures responsible for separation in principal component analysis. This study provides a robust framework for understanding the processes and patterns of REEs in pedogenesis across landscapes.

ACKNOWLEDGEMENTS

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GT 01 - 191 - O

PEATLAND FORMATION AND COASTAL PLAIN EVOLUTION IN SOUTHEASTERN BRAZIL: UNRAVELING THEIR INTERCONNECTIONS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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We investigated the interrelationships between forested peatland formation and coastal plain evolution during the Holocene in the lower Ribeira de Iguape River Valley, São Paulo, Brazil, focusing on sea-level variations and fluvial reshaping of the landscape. These peatlands show exceptional carbon accumulation and, locally, thiomorphic Histosols with high methane production. The swamp forests include both Histosols and Gleysols, making soil mapping at regional and local scales a complex task.

Using a multiproxy approach—including pedological, stratigraphic, paleoecological, and remote sensing analyses—we mapped peat-rich soils and associated landforms across a 280,000 ha area. Morphosedimentary mapping was based on photointerpretation and soil profile descriptions, supported by OSL dating and sedimentary facies analysis. Regional mapping of organic soils and peat depth prediction used machine learning and multispectral data. At the local scale, Histosols and Gleysols were distinguished using LiDAR-derived canopy metrics and machine learning. Field validation was performed using a russian peat sampler. Marine influence was also inferred from thiomorphic features along a NW–SE transect.

Regional models achieved Kappa > 0.91 and peat depth RMSE < 37 cm. LiDAR metrics such as maximum canopy height, 10 m percentile, and asymmetry differentiated soil-vegetation structures, with a local-scale model achieving Kappa = 0.82, demonstrating the utility of LiDAR for soil discrimination in forested wetlands.

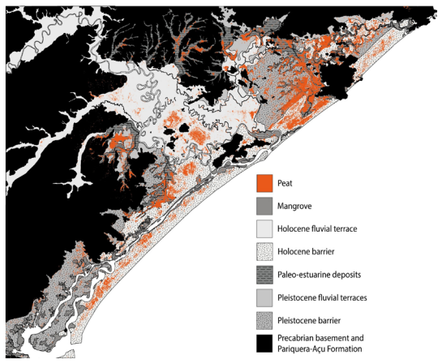
During MIS1, incised valleys were flooded by the sea via paleo-estuarine mouths, forming ria-type estuarine-lagoon systems. Around 3,800 years BP, regressive barriers isolated estuarine channels. Hydrophytic vegetation colonized these areas, leading to peatland development through terrestrialization and paludification. The mapped peatlands are in former estuarine valleys now acting as paleoestuaries. These processes coincided with periods of sea-level stability or slow regression, fostering waterlogged conditions favorable for organic matter preservation. Sulfidization is common in the Histosols due to marine transgressive phases. Stratigraphic sequences and OSL/radiocarbon dates point to peat formation primarily during the mid- to late Holocene.

This study improves understanding of how southeastern Brazil's coastal plains responded to Holocene sea-level changes. Peatlands are highlighted as significant paleoenvironmental archives.

Based on updated analyses, we refined a previous semidetailed survey estimate of 70,000 ha to 36,706 ha of Histosols, containing 0.379 km³ of peat and 24 million tonnes of carbon, with an average stock of 656 $t \cdot ha^{-1}$ and mean peat depth of 109cm.

ACKNOWLEDGEMENTS

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Morphosedimentary Units and Peatland Occurrence in the Coastal Plain of the Lower Ribeira de Iguape Valley (SP, Brazil)

GT 01 - 195 - O

DRIVERS OF THE SPATIAL DIVERSITY OF CHERNOZEMS AND ACCOMPANYING SOILS IN THE TARBAGATAI MOUNTAINS, SOUTH-EAST KAZAKHSTAN

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Tarbagatai National Park located in south-east Kazakhstan at the border with China is a medium-high mountain range surrounded by steppes and covered with loess and loess-like sediments to an altitude of nearly 2000 m a.s.l. An elevation-related climatic gradient has been considered to trigger soil zonality from the foothills to the upper slopes, consisting of kastanozems, steppe chernozems, and mountain-meadow chernozems, respectively. The investigations carried out in the foothills and southern slopes of the Tarbagatai Mountains aimed to analyse the spatial diversity in relation to geological, geomorphological, and climatic factors and to verify the spatial correlation of soil units on local and global soil maps, prepared using the FAO Legend and the WRB classification. The study confirmed a general predominance of soils with humus-rich, dark-coloured, and base-saturated mollic horizons. Chernozems and Phaeozems, in terms of WRB classification, were identified parallelly in all climate/vegetation zones within the elevation range of 500 to 1200 m a.s.l. Local relief differentiation, associated with erosion/accumulation phenomena, rather than elevation, was considered the main factor influencing the presence of secondary carbonates in soil profiles and local soil differentiation into Chernozems and Phaeozems. The chernic horizons were widely spread of the arable soils in the foothills, where Kastanozems were previously identified as the dominant soil group. Whereas, the foothill Kastanozems, which met the WRB criteria, were identified mostly in locations prone to erosion. The results may suggest the need to verify the classification criteria for Kastanozems in the WRB system or to verify the traditional opinions on the zonality of chernozemic soils in the mountain and submountain areas of the south Kazakhstan.

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GT 01 - 228 - O

IS MAGNETIC SUSCEPTIBILITY USEFUL IN FOREST SOIL CLASSIFICATION?

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Current soil classification systems are based on diagnostic horizons, some defined by iron content and forms. It is expected that these diagnostic horizons, as well as the entire vertical soil profile, will show characteristic magnetic properties. Magnetic parameters may be useful for rapid identification of certain soil types. Here we present preliminary data from the following soil types: podzolic soils (Albic Podzols, Ortsteinic Podzols), rusty soils (Dystric Brunic Arenosols), ochre soils (Tsitelic Arenosols, Rubic), and soils containing bog iron ore (Gleysols, Limonic). The soil pits were located in various parts of Poland, both in relatively pristine areas and in regions affected by atmospheric deposition of industrial dust. The soil pits were excavated to a depth of about 1.5 meters. At each site, vertical distribution of magnetic susceptibility (κ) was measured. Representative soil samples were collected from individual diagnostic horizons for further chemical (total content and pedogenic forms of Fe, Al, and Mn), mineralogical (Mössbauer spectroscopy), and thermomagnetic analyses.

In podzolic soil profiles, the highest κ were measured in the uppermost organic horizon, where technogenic magnetic particles (TMPs) accumulate upon atmospheric deposition. The magnetic peak in the organic horizon was significantly higher in industrial areas (>100 $\times 10^{-5}$ SI units) compared to relatively clean areas (30–40 $\times 10^{-5}$ SI units). Below, in the eluvial E horizon, κ decreased close to zero or even negative - diamagnetic values. A slight increase in κ was observed in the Bhs spodic illuvial horizon, although values remained below 10 $\times 10^{-5}$ SI units. If the C horizon consisted of pure quartz sand, κ again dropped close to 0. The magnetic profile of rusty soils was more stable. The diagnostic sideric horizon Bw, although slightly enriched in total Fe, exhibited κ between 5 and 15 $\times 10^{-5}$ SI units due to the presence of paramagnetic or poorly crystalline forms of iron. Ochre soils displayed very distinctive and high κ values. In some cases, the κ in the B horizon exceeded 2000 $\times 10^{-5}$ SI units, while horizons above (AB) also showed high values (>100 $\times 10^{-5}$ SI units). This is attributed to the concentration of ferrimagnetic ferrihydrite and fine-grained maghemite, whose presence was confirmed by Mössbauer spectroscopy and thermomagnetic analyses. Despite the much higher total Fe content (up to 300 g/kg) in certain h ydromorphic soils, which contain bog iron ores, the κ signal was significantly lower (<500 $\times 10^{-5}$ SI units). These ores are primarily composed of ferrous substances with varying degrees of goethite recrystallization. In conclusion, all the investigated soil types exhibit characteristic magnetic profiles, which may assist in their identification.

ACKNOWLEDGEMENTS

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GT 01 - 379 - O

TEMPORAL EVOLUTION OF BIOSPHERIC AND WEATHERING-INDUCED C DRAWDOWN ALONG A ONE-MILLION-YEAR SOIL CHRONOSEQUENCE

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The Galápagos archipelago, a chain of islands formed by hotspot volcanism on the Nazca tectonic plate, displays a pronounced gradient in rock age, increasing from west to east with distance from the volcanic hotspot. In this study, we investigated soil organic carbon (SOC) accumulation and chemical weathering along a humid soil chronosequence spanning 1.5 to 1070 ka.

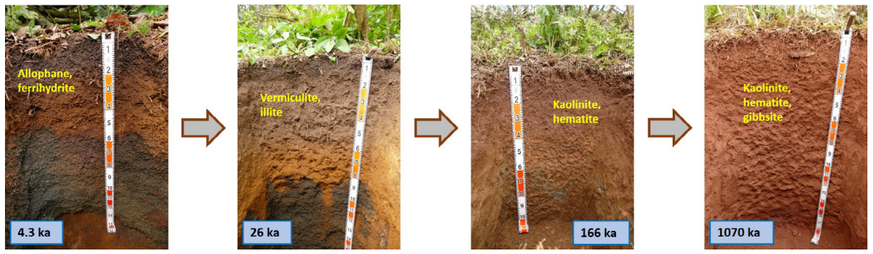
Our findings reveal rapid SOC accumulation during the early stages of soil formation, with an initial peak in SOC stocks (21.5 kg/m2) at 4.3 ka. This phase is characterized by the dominance of short-range-order minerals in the colloidal fraction, which efficiently stabilize organic matter. SOC stocks subsequently decline to approximately 15 kg/m2 at intermediate soil ages, where 2:1 and 1:1-type clays dominate, before reaching a second peak (25.5 kg/m2) in late pedogenesis (1070 ka), when pedogenic oxides play a key role in organic matter stabilization.

Chemical weathering was marked by significant base cation losses during the early to intermediate phases, with 95% of Na and 78% of Mg lost from the topsoil by 26 ka, and near-complete depletion from the entire soil profile in soils older than 800 ka. Silicon depletion was less pronounced, with topsoil losses of 24% by 26 ka and 63-68% in soils older than 800 ka. Total weathering fluxes and associated CO_2 consumption rates, estimated from profile-scale element losses, exceeded global average values during the early weathering phase but declined significantly in the intermediate and late phases.

Carbon drawdown during early pedogenesis (≤4.3 ka) was dominated by SOC sequestration (70-90% of total C drawdown), whereas inorganic, weathering-induced CO_2 consumption became the dominant process (90-95% of total C drawdown) in the intermediate and late phases (≥166 ka). These results highlight that young volcanic surfaces act as highly efficient C sinks, both organic and inorganic, and that the relative contributions of biospheric versus geologic carbon drawdown shift substantially over the course of soil and ecosystem evolution.

ACKNOWLEDGEMENTS

This study was conducted under research permit no. PC-60-16 of the Galápagos National Park Directorate (GNPD) and supported by the Prometeo Project of Ecuador's Secretariat of Higher Education, Science, Technology and Innovation (SENESCYT). We are very grateful to the many national park rangers as well as technicians of the Ecuadorian Ministry of Agriculture and Livestock for their invaluable hands-on help in the field. We also thank the Charles Darwin Foundation for logistic support in Galápagos.



Selected soil profiles and dominant secondary mineral phases along the studied chronosequence.



GT 01 - 479 - O

RECONSTRUCTING PALEOCLIMATOLOGY IN LATE HOLOCENE IN KONAR SANDAL, SE IRAN USING BIOMARKERS IN PEAT SOILS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The Jiroft Valley in southeastern Iran, a key Early Bronze Age centre for agriculture and trade, offers a valuable paleoenvironmental archive to understand the correlation between climate and human settlement. A 250-cm peat core from near the Konar Sandal archaeological site was analysed for archaeal and bacterial glycerol dialkyl glycerol tetraethers (GDGTs) to reconstruct climate variability and depositional conditions during the late Holocene.

Paleotemperatures derived from the MBT/CBT index (de Jonge et al., 2014) revealed three major thermal maxima around ~3143, ~1985, and ~1400 cal yr BP. The first two peaks (~3143 and ~1985 BP) coincide with arid phases, suggesting heatwave–drought events that may have contributed to societal stress and decline at Konar Sandal, consistent with broader regional disruptions in the Eastern Mediterranean (Gurjazkaite et al., 2018; Vaezi et al., 2022). The ~1400 BP warm phase, however, occurred under wetter conditions. Peat layers from ~3143 and ~1400 BP showed signs of oxic degradation, while the 1985 BP layer—characterized by gyttja with plant remains—suggested a higher water table and enhanced preservation. These findings highlight that warming was not uniformly associated with drought, as also noted by Gurjazkaite et al. (2018).

The Methane Index (MI; Zhang et al., 2011), indicating redox conditions, peaks at ~3700 and ~1700 BP in conjunction with low pH, pointing to increased methanogenesis under anoxic, saturated conditions. A long-term MI decline toward the top of the core reflects progressive drying and peat oxidation. Microbial lipid abundance further shows that both archaeal and bacterial biomasses increased during wetter periods, suggesting heightened activity of methanogenic and ammonia-oxidizing microbes.

The Branched and Isoprenoid Tetraether (BIT) index (Hopmans et al., 2004), shows low values in gyttja-rich layers. This inverse relationship indicates a greater contribution of aquatic microbial lipids during these intervals, supporting evidence for sustained waterlogging and wetter conditions.

Overall, GDGT-based biomarkers provide robust insights into late Holocene climate and hydrological shifts in southeastern Iran, enhancing our understanding of environmental influences on ancient human systems.

ACKNOWLEDGEMENTS

CH acknowledges funding from Humboldt Foundation (Humboldt Research Fellowship for Experienced Researchers).

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GT 01 - 514 - O

POSTGLACIAL AGRICULTURAL LANDSCAPE SOILS - GENESIS, CLASSIFICATION AND MAPPING

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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In the conditions of the complex undulated topography, formed by the glacier and its meltwater, large-scale soil mapping (1:10000) according to the WRB (2022) system faces significant challenges in Latvia. A large diversity of Reference Soil Groups (RSG) and qualifiers is found in a relatively small area. The aforementioned diversity is not related to specific factors, however, the influence of a set of soil-forming factors (the effect of soil moisture and its vertical changes of water flow due to variation of soil granulometric composition, erosion processes, soil drainage and constuction of drainage/melioration systems, land use). In a relatively small area, the soil cover is formed by Luvisols, Retisols, Regosols, Stagnosols, Gleysols, Phaeozems, Planosols, Podzols, Histosols and Anthrosols soils with their corresponding sets of qualifiers.

The mapping units of individual RSG and especially their qualifiers in many cases are detected in spatially very small areas, therefore problems rise of its representativeness and soil mapping at a scale 1:10000. The spatial distribution of the RSG and its qualifiers in many cases is not related to relief forms, which may create great challenges in the future soil mapping by using digital methods. In data comparison of historical soil maps (genetic soil classification) of Latvia at a scale of 1:10000 and the WRB (2022) soil map – it is observed that spatial soil mapping units or contours do not coincide spatially.

This study confirmed the feasibility of the RSG use according to the WRB (2022) in large-scale soil mapping of agricultural lands in the post-glacial landscape. The use of RSG qualifiers of the WRB in the allocation of soil mapping units in conditions of complex topography and geological deposits (mapping at a scale of 1:10000) is possible only by increasing the sampling density. Historical soil maps of Latvia – produced by using the genetic soil classification, cannot be used as a basis for the allocation of soil mapping units according to the WRB, since the classification principles differ and changes in soil properties were detected as a result of agricultural land drainage/melioration and liming.

The results of the study were used in the development of the 2023 version of the Latvian Soil Classification System and soil mapping guidelines at a scale of 1:10 000 and these results is published by Nikodemus et al. (2024).

ACKNOWLEDGEMENTS

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GT 01 - 526 - O

TOWARDS THIRD GENERATION SOIL FORMATION MODELS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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One of the key challenges in the field of Soil science in general and Pedometrics specifically is, can we produce quantitative models of the complex short and long-term processes of soil formation which are predictive of the spatio-temporal variation of soil properties? Currently, we have advanced understanding of different soil processes, but we are still lacking an overarching process-based model capable of simulating soil formation and evolution.

This paper aims to summarize over two decades of research in this area, from the first generation of soil formation models integrating geomorphic transport laws and simple soil formation rate expressions, over second-generation soil formation models focusing on soil genesis (e.g. Soilgen, SSSPAM, mARM, MILESD, LORICA), to line out the challenges before us for the new generation of third generation soil formation models. In spite of its importance, this field has received relatively little attention. For example, in the ISMC database there are 46 models, but only 1 pedogenesis model. A community effort is therefore needed to move this project further, spanning soil sciences, geology, geomorphology, ecology and plant sciences. In many of these fields, important recent advances in process understanding are highlighted that should be integrated in the models. One important step has been the explicit inclusion of water-balance driven soil formation at the landscape scale (hydro/chronoLORICA).

For the future of these 3rd gen soil formation models, there is a growing focus on integrating them with other scientific disciplines, leveraging computational power, and developing tools that are accessible and useful to a wider range of users. Furthermore, incorporating emerging technologies like machine learning and data assimilation can enhance their accuracy and efficiency.

GT 01 - 532 - O

PEDOLOGICAL TRANSECT SURVEYS TO ENHANCE DATA QUALITY FOR REGIONAL DIGITAL SOIL MAPPING

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The Swiss canton of Bern aims to delineate multifunctional soil maps supported by a digital soil mapping (DSM) approach, integrated in the nationwide cartography. As large regions of this geologically diverse canton are pedologically unknown, we have undertaken an overview survey to unravel the feature space and provide initial data for the sampling design. Furthermore, we have identified practical and pedological challenges, e.g., related to classification, and created educational material to support the future mapping campaign.

To this end, we have selected 42 transects of 3-4 km length by their geological diversity through geostatistics and expert assessment. Field pedologist selected 15-20 representative hand-auger positions in each transect, based on available geodata and on-site assessment. Around two profiles per transect (n = 108) were selected as regional references and analyzed in further detail. The obtained soil data were assessed and harmonized before further analysis.

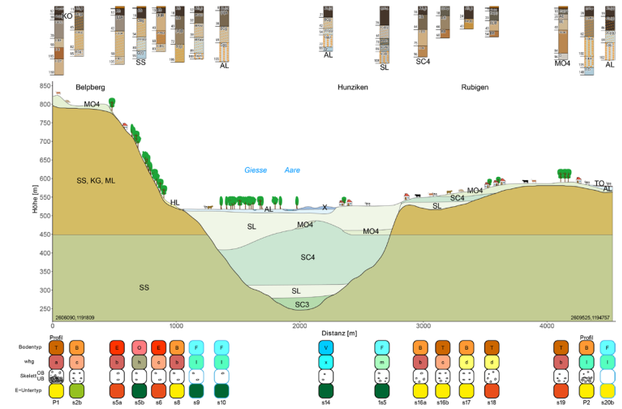
R-plots served in pre-visualizing soil-landscape profiles, of which 28 were elaborated in detail. The final plots show the profile positions with key pedological data, geology and land use. Reference profiles helped to understand soil evolution and reach a consistent classification elaborated in the quality assessment. Finally, a large range of soil attributes were predicted for multiple depths using random forest, and a wide range of environmental covariates.

Because of the integration of DSM-methods as well as spectroscopy into the Swiss mapping method and budget restriction for the nationwide cartography, the sample density will drop dramatically compared to the previous mapping method. Thus, the importance of high-quality survey of each single sample increases, especially for non-measurable soil function parameter like the rootable soil depth, which is crucial for legal decisions in land use planning.

Our study identified classification problems and provided solutions for a consistence and high-quality data collection through the transfer of knowledge of a soil-landscape understanding in combination with the observable specifications in the soil profiles. The visualisation, description and discussion of the soil data with respect to their environment are educational material for future field pedologists. Additionally, all kinds of soil property maps can serve as covariates for the intended feature space coverage sampling designs in the planned soil mapping of the canton of Bern.

ACKNOWLEDGEMENTS

We are very grateful for the initiation, support and funding of this work by the Office for Agriculture and Nature of the Canton of Bern and the Wyss Academy for Nature



Example of a visualised pedological transect in the quaternary overprinted molasse basin in the canton of Bern



GT 01 - 576 - O

COLLUVIUM-PEDOGENESIS RELATIONSHIP IN THE OPEN-AIR ARCHAEOLOGICAL SITE OF BASTOS (SÃO PAULO/BRAZIL): 13,000 YEARS OF SLOPE EVOLUTION

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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The Bastos Archaeological Site, located in the municipality of Dourado, in the interior of São Paulo state (Brazil), is currently the oldest in the state with evidence attributed to hunter-gatherer groups during the Pleistocene-Holocene transition. Situated at the bottom of a slope, the site presents a geomorphological context conducive to the preservation of anthropogenic remains favored by successive depositional events that protected the records over time, being an open-air archaeological site. The bottom of slope where the site is located presents an alluvial fan, and lithic artifacts ranging between 12.6 and 3.9 ka. The objective of the research is to correlate colluvium events and soil formation, using archaeological evidences applying a combination of soil morphological description, archaeological survey, chemical and granulometric analysis, soil micromorphology, and Carbon-14 dating. Three profiles of buried Nitisols and one adjacent reference Nitisol have been described, separated by paleo-surfaces that truncated the A horizons from the three bottom profiles. The time interval between deposits allowed the formation of Nitisols with well-developed blocky structures and abundant clay skins, indicating that the time interval (between 4,000 and 5,000 years) was sufficient to form Nitisols with highly developed pedo-features. A concentration of lithic artifacts close to the contact with the paleosurface indicate colluvial deposition at 12.9, 8.7 and 3.9 ka. In addition to the upper deposits, the bottom alluvial deposit presents undated archaeological artifacts indicating that the settlement is at least 12.9 ka. The slope dynamics indicates that periodic short-term mass movement events mobilize soils from the upper slopes forming alluvial fans downslope, not necessarily associated with changes in environmental conditions.

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GT 01 - 620 - O

TIMING AND CAUSE OF THE ONSET OF ENHANCED EROSION-SEDIMENTATION DYNAMICS IN MONGOLIA - CLIMATIC SHIFT OR HUMAN IMPACT?

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 05. SOIL HYDROLOGY & EROSION

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This project focused on two questions: 1) When did the erosion-sedimentation dynamics in Mongolia start? 2) Which factors triggered their onset? To tackle these questions, we analyzed profiles in stratified overbank deposits in several regions across Mongolia for particle size distribution and organic carbon content, and subjected suitable samples to luminescence or radiocarbon dating, respectively.

The deposits were composed of alternating alluvial and aeolian layers, humous layers of eroded topsoil material, and paleosols. We interpret this alternation as follows: The alluvial sediments accumulated during flood events. After their deposition, the bare sediment surface was exposed to deflation and aeolian sediment redeposition, before vegetation reestablished and stabilized the surface again.

The erosion-sedimentation process must have been triggered by increased surface runoff causing flooding, and by accelerated soil erosion in the catchments providing the sediment. A decline in vegetation cover may explain both: It would cause increased surface runoff and reduced protection of the soil surface by vegetation, which would lead to erosion.

The obtained ages suggest that the main formation period of the sediment sequences started only around 2000 years ago. The onset of the erosion-sedimentation dynamics might have been caused by a climate change towards more concentrated heavy precipitation events and longer droughts, the latter leading to vegetation decline. However, the various paleoenvironmental reconstructions reported in the literature do not point to a pronounced climate change 2000 years ago. Some of the archives rather point to a shift towards more humid conditions about 3000 years ago (Klinge and Sauer, 2019). Thus, it is more likely that anthropogenic logging of forests, use of fire, and intensification of animal husbandry led to enhanced surface runoff and accelerated soil erosion around 2000 years ago.

Archaeological evidence of animal husbandry in Mongolia goes back to about 5000 years ago, with the Afanasievo, Okunev and Andronovo cultures. However, substantial human impact on the landscape apparently only began 2000 years ago, with the Xiongnu culture, Turkmen, Uyghurs, Kyrgyz and Mongols, prevailing one after the other. This time seems to mark a turning point of enhanced increase in population, accompanied by increased grazing pressure.

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GT 01 - 635 - O

PROTO-SOILS OF EXTREME ENVIRONMENTS: A WINDOW INTO PRECAMBRIAN MODES OF SOIL FORMATION

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 04. SOIL BIOLOGY

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A large portion of modern land is covered by proto-soils formed in the absence of vascular plants and their root systems. Such soil bodies are common in a variety of extreme environments, e.g., ice-free areas of Antarctica, High Arctic, hot deserts and high mountains. Those proto-soils that are shaped exclusively by microorganisms provide the best available real-time models for approximating the initial stages of soil formation in the Precambrian. Here, we focus on the properties of microbially driven proto-soils formed in endolithic, hypolithic, and supraglacial settings. The presentation is based on the data we collected on the structural organization and composition of such proto-soils with the use of scanning electron microscopy, energy-dispersive X-ray spectroscopy (incl. “MAPS mineralogy”), FTIR and Raman spectroscopy, X-ray computed microtomography, and other techniques. We show that the microbial origin of proto-soils does not necessarily imply simplicity of their profiles. Organogenous layers, e.g., those dominated by cyanobacteria, are often complemented by associations of paragenetic microhorizons and even microscale patterns of eluvial-illuvial differentiation. Just as common soils do, microbially driven proto-soils contain OM pools of various ages, from recent to millennia old. They are capable of long-term stabilization of carbon through occlusion, formation of multi-layered aggregates, adsorption on active mineral surfaces, formation of clay-EPS assemblages, hydrophilic-hydrophobic interactions, and other processes. Well-preserved and readily assessed indicators of modern microbially driven proto-soils include polyenes (carotenoids), calcium carbonate polymorphs (calcite, aragonite), SiO2 coatings, Fe-containing compounds and their associations with OM, stable isotope ratios of C, and paragenetic associations of microhorizons. Knowledge of the structural organization and composition of modern proto-soils is becoming increasingly valuable with the rapid growth of geochemical, paleontological, and paleogenetic data on Precambrian ecosystems on land. Combining these data opens new “windows” into ancient soil covers.

GT 01 - 639 - O

EARLY PEDOGENESIS OF A YOUNG TECHNOSOL MADE FROM ORGANIC WASTES

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Constructed soils based on urban waste, i.e. Technosols appear as a promising solution to enhance circular economy while delivering ecosystem services. Their ability to provide such services depend on their constitution as well as on their temporal evolution and pedogenesis, which is poorly known. We studied during three years the changes in an isolatic Technosol made essentially of organic urban wastes.

The study took place on a Parisian rooftop with an experimental trial of 24 plots. We compared four Technosols with similar upper layers (a mix of biowaste compost and spent mushroom substrate), but with either a mineral (shredded tiles and bricks) or an organic lower layer (shredded wood). Both types were run with and without plants. Technosols were monitored over three years and samples were taken at different times to study pedogenetic processes.

We observed a rapid and sharp volume loss of the Technosols, responsible for an important mass loss, but not leading to any increase in bulk density. A clear physico-chemical differentiation of treatments from the parent materials appeared after one and three years. The Technosoil organic C stocks decreased over time. During three years, all Technosols were a net source of nitrogen and dissolved organic carbon, released in the drainage waters. Identified pedogenesis processes were the same as in natural soils, but the changes were very fast. The key equilibrium between mineralisation of organic matter and its stabilization that must be ensured when creating such Technosols. They show the necessity for long term research on the development of Technosols.

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GT 01 - 640 - O

PALEOSOL-SEDIMENT SEQUENCE AS ARCHIVE OF UPPER PALEOLITHIC ENVIRONMENTS OF THE KOSTENKI 17 SITE (VORONEZH REGION, RUSSIA).

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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The Kostenki-Borshevo archaeological complex, situated on the right bank of the Middle Don River near the villages of Kostenki and Borshevo, comprises 26 Upper Paleolithic sites (Holliday, 2007; Velichko et al., 2009). Reconstructing the paleolandscapes of Kostenki is crucial for understanding the environmental conditions faced by Paleolithic societies in Eastern Europe during the last glacial period (Hoffecker et al., 2008; Sedov et al., 2022; Panin et al., 2019; Sinitsyn, 2015). Despite extensive paleosol and geological research, key questions regarding the genesis, evolution, and formation conditions of these paleosols remain unresolved. This study focuses on the Kostenki 17 (K-17) site, which contains one of the most stratigraphically complete paleosol-sediment sequences in the region.

This investigation examines the topography and colluvial paleosol-sediment sequence at K-17. Our methodology integrates geodetic surveys, drilling, tephrochronology, and a suite of soil-lithological analyses, including grain size distribution, loss on ignition (LOI), X-ray fluorescence (XRF), total organic carbon (TOC), and macro- and micromorphological techniques.

The results of the research made it possible to identify six stages of the paleosol-sedimentary sequence K-17. We have shown that the K-17 site is not part of a river terrace, as was often previously believed, but belongs to a colluvial cover leaning against the base of the bedrock slope of the valley. Convincing evidence was found for the presence of permafrost and solifluction process, which deformed the Upper Humic Bed (second part of MIS 3), containing cultural layer I. Additionally, we have identified that the formation of the paleosols within this upper humic layer was significantly impacted by humans. The high saturation of wood and bone charcoal, as well as artefacts, point to an anthropogenic influence on soil formation. We made the assumption that the site was chosen for settlement by Paleolithic humans based on its geomorphological position.

ACKNOWLEDGEMENTS

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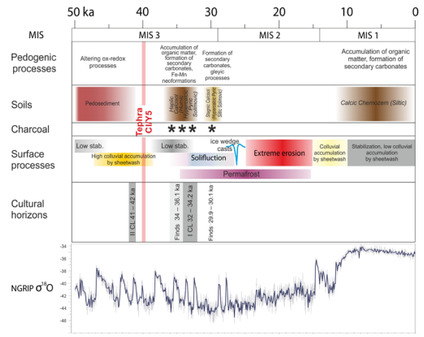
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Main surface and pedogenic processes of the K-17 paleosol–sediment sequence formation.

GT 01 - 668 - O

PEDOMETRICS SUPPORTED EVALUATION OF CLASSIFICATION OF HYDROMORPHIC SOILS USING TRADITIONAL LABORATORY AND SPECTRAL SOIL DATA

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Hydromorphic soils form under conditions of temporary or permanent water saturation, leading to the development of redoximorphic features characterised by the reduction and/or localized segregation of iron.

The classification of hydromorphic soils is based on the definition of the expression, thickness, and depth of occurrence of redoximorphic features, as well as the presence of reducing conditions. As the collection of these data requires a detailed soil description, both national and international soil databases often lack sufficient information on redoximorphic features, which makes the classification of hydromorphic soils difficult.

To overcome these challenges, taxonomic distance calculation methods have been increasingly used to evaluate relationships between soil classification units.

In recent years, traditional laboratory data have been successfully supplemented with mid-infrared (MIR) and visible–near infrared (Vis–NIR) spectral data, improving the interpretation of taxonomic relationships among soil types. Since iron compounds play a key role in hydromorphic soil development, and have distinct spectral signatures, both MIR and Vis–NIR spectroscopy offer valuable tools for characterising such soils. While MIR spectroscopy has proven effective in identifying some characteristic features of hydromorphic soils, Vis–NIR spectroscopy often performs better in detecting iron-related attributes.

The aim of this study was to compare the taxonomic distances of hydromorphic soil centroids based on traditional laboratory data and spectral datasets (MIR and Vis–NIR), and to assess the potential of the studied spectral methods in supporting the classification of hydromorphic soils. The analysis was carried out based on 70 Hungarian hydromorphic soil profiles and the archive data of 1200 profiles of the Hungarian Soil Information and Monitoring System (SIMS).



GT 01 - 688 - O

THE NEED TO UPDATE POLISH SOIL MAPS IN THE CONTEXT OF TRANSFORMATIONS OF ORGANIC SOILS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Poland possesses excellent soil cartographic materials at various scales. These include, among others, soil valuation maps and agricultural soil maps. The soil valuation maps present the results of the nationwide soil classification conducted in the 1950s and 1960s. The content of these maps includes: (1)the type of landuse, (2) soil valuation class, (3) soil units (types) of arable, forest and permanent grassland, (4) soil parrent material and (5) soil texture.

The study was conducted in the south-western part of the Northern Masovia Lowland macroregion. One rural municipality was selected, and from the soil valuation map at a scale of 1:5,000, soil were identified as organic ones, and used as arable land. The aim of the study was to assess whether the soils within these contours still meet the criteria for organic soils and whether they are still used as arable land. In the selected rural municipality, 151 soil contours meeting the above criteria were identified. The total study area covered 580.96 hectares. The size of individual contours ranged from 0.04 to 49.34 hectares. A total of 303 soil profiles were made and described. A rule of one soil profile per 3 hectares was adopted. In the field, soil horizon thicknesses, particle size distribution, land use type, and soil type were determined. Soil samples were also collected for laboratory analysis, where ash content, soil pH, organic carbon, and total nitrogen were measured.

A significant change in the land use was found within the examined contours. The dominant land use was permanent grasslands (43.23%), followed by arable land (35.97%) and forests (19.80%). Wastelands (0.33%) and built-up areas (0.66%) were also recorded. Analysis of the soil profiles revealed that the dominant soil type included black earths (57.48%), followed by organic soils, mainly peat and mursh soils (37.87%), and brown soils (3.99%).

An attempt to determine the reason for the significant discrepancies in soil typology was also made. It was estimated that 49.83% of the analyzed soils profiles, were incorrectly classified as organic soils during the nationwide soil classification and the creation of the soil valuation maps. In 11.96% of cases, changes in soil classification occurred due to natural evolution processes, namely the mineralization of organic matter as a result of prolonged drainage, leading to their transformation into mineral-organic (post-murshic) or mineral soils (most often black earths).

GT 01 - 752 - O

THE ISRIC GLOBAL SOIL ARCHIVE: A VALUABLE RESOURCE

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 16. CONNECTING PEOPLE AND SOILS

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In 1961, FAO and Unesco started the preparation of the Soil Map of the World (SMW) at 1:5 000 000 scale. It was the first concerted effort to create a soil map at the global scale with contributions from 133 national institutes that provided maps and data. A methodology was designed to order the soils of the world in classes and produce an overview of soils with a unified, international legend. The SMW project was a first appraisal of the World's soil resources and was completed over a span of twenty years.

ISRIC was established soon after the start of the SMW project, in 1966. It would safeguard all survey reports and maps gathered in the SMW project. Also, the International Soil Museum, later renamed to ISRIC (International Soil Reference and Information Centre), was to build a collection of soils according to the legend of the SMW. It would provide a reference of soils of the world and a scientific basis for the legend of the SMW and for the soil classification system that would evolve from it, the World Reference Base for Soil Resources (WRB). Hence, since 1966, ISRIC has established a reference collection and collects, documents, studies the soils of the world, contributes to standards for analysis, description and classification and provides a global overview of soils and their properties.

The ISRIC World Soil Reference collection consist of: about 1000 soil monoliths (undisturbed samples from a profile wall and conserved with lacquer and glued to a board for display in our museum) from 75 countries, 5000 soil samples with physical and chemical data, 3500 thin sections, photographic documentation of soil (site and soil profile). These samples have been collected and analyzed in a consistent way, according to international standards1,2, and 75% are considered reference soils: complete descriptions, monoliths with accompanying sample material, data from certified, reference lab, characteristic of the map units of the FAO Soil Map of the world.

The soil monoliths provide unique source for education and advocacy. The samples of the reference collection are used for a wide variety of purposes across the world. Examples are: 1) creation of a global reference IR-spectral library for various soil attributes (ICRAF, Kenya), 2) comparison of pre- and post-Chernobyl soil conditions in the Middle East (ICARDA, Syria) to assess the impact of nuclear fall-out on soils, 3) research on caesium behaviour in a variety of soil types throughout the world by UCL (UCL, Louvain-la-Neuve, Belgium, and 4) assessment of soil biota richness and composition through assessment of soil DNA.

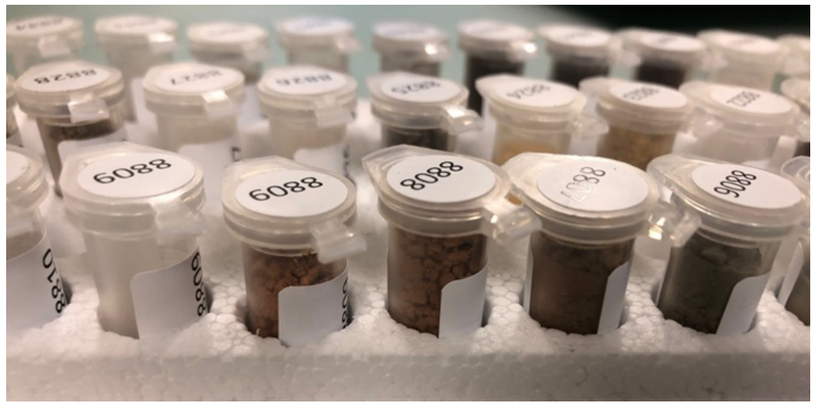
KEY WORDS:

Reference collection, monoliths, samples, global

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GT 01 - 824 - O

SOIL FORMING ENVIRONMENT AND GENESIS OF THE WORLD SOIL OF THE YEAR 2025 – A GLEYSOIL FROM THE CARPATHIAN-BASIN.

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 16. CONNECTING PEOPLE AND SOILS

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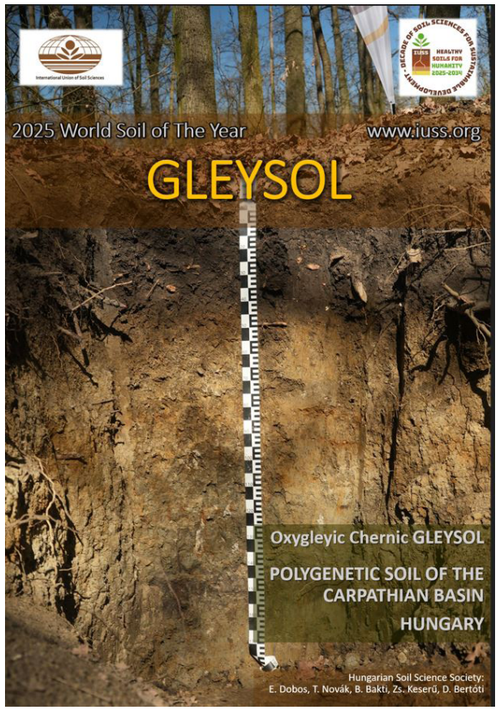
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This soil association and soil-landscape developed in this environment created a special and unique cultural landscape dominated by grasslands and salt effected pastures in the Hungarian Plain. Its unique folklore and culture was recognized by the UNESCO World Heritage committee and the surrounding area was dedicated as World heritage site and a Biosphere Reserve area. The actual soil profile is located within the Forestry Research Institute Püspökladány (Farkassziget) Salinization Experimental Yard that was founded on 1 October 1924, 100 years ago to elaborate methods of afforestation on less fertile, low productivity lowland areas with relatively dry climatic conditions and salt affected saline soil. The major research areas focus on the selection of tree and shrub species for afforestation and forest management that are based on natural processes and can be applied to forest steppe climate. The aim is to improve the ecological stability, game bearing capacity, and the economic value of these forests by combining knowledge from different fields of sciences focusing on the biosphere, hydrosphere, lithosphere, pedosphere and atmosphere, for sustainability, carbon sequestration and climate change adaptation. These soils maintain natural and planted forest patches and provides diverse research, experimental, recreational and educational functions.

The soil forming environment is a fluvial landscape with depositional features in the middle of the Carpathian Basin. The area is a typical backwater area, a closed depression bordered by the natural levees of abandoned river channels, creating a unique soil association with Gleysol, Solonetz and Chernozem soils. The area was drained in the second half of the 19th century and its rivers lost their water supplies or were transformed to drainage or irrigation channels. This is a beautiful polygenetic soil profile having several different soil formation stages and changing soil development accordingly, inheriting the properties and changing them to adapt to the current environment. It has a buried soil layer at 145-155 cm depth representing an older surface with heavy clay texture of fluvio-lacustrine origin. It was later covered with coarser textured fluvio-aeolian sediment with increasing amounts of aeolian deposits mixed into the clayey material. The buried soil with very fine clay sediments shows beautiful vertic properties and slickensides. Due to its low lying position and its closed basin nature, the soil shows stagnic and gleyic properties at the same time (uterqic). It was developed under the influence of shallow, salty groundwater, and frequent, seasonal water-stagnation at the soil surface at the same time, accompanied with some slights salt accumulation in the deeper horizon. From the buried soil to the recent soil and its actual development (after water regulations) the influence of the groundwater is decreasing, but it still supports forest growth in relatively dry climatic conditions.



GT 01 - 837 - O

LESSONS FROM THE CORRELATION OF THE SOIL TYPES OF THE MODERNIZED, DIAGNOSTIC BASED HUNGARIAN SOIL CLASSIFICATION SYSTEM WITH THE REFERENCE SOILS GROUPS OF THE WRB

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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A diagnostic based Hungarian Soil Classification System (HSCS) has been developed ont the foundation of accumulated experiences with the traditional genetic system and the pedometric evaluation of national data collected is the past decades. The definitions and limits of the diagnostic categories (horizons, materials and properties) correspond with the World reference base for soil resources (WRB 2015), but are not identical. They are much simpler, and adopted for the soil forming environmental setting of the Carpathian Basin. The central units are the 15 soil types are defined by the newly introduced computers assisted classification key.

The 15 soil types were correlated with reference soils groups of the WRB (2015). The correlation was supported by the application of taxonomic distance calculations. For the numerical studies legacy data of the Hungarian Soil Monitoring System and ISRIC-WISE Harmonized Database were applied. For the better understanding of trashold values of the elements of classification systems the database of the IUSS Universal Soil Classification Working Group data base and spectral data were also considered. The results include expected and unexpected matches and dismatches between the HSCS and WRB units. The paper will discuss the lessons of the correlation studies. It will include critical evaluation of complicated details in the WRB which may not be necessary for the same classification results and expected interpretation. In case of dismatches optional reasons will be will be discussed. The correlation and evaluation work will be examplified on well studied soil pedons.

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GT 01 - 861 - O

EFFECT OF ROCK FRAGMENTS ON SOIL ORGANIC CARBON STOCK ESTIMATION AND MAPPING IN FOREST SOILS OF THE CZECH REPUBLIC

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Forest soils represent a very important pool of soil organic carbon (SOC) and proper management of these soils can mitigate climate change. Proper estimation and spatial prediction of SOC stocks in forest soils is thus crucial. However, soil surveys often determine only SOC content (in % or g/kg), so that the SOC stock assessment needs an estimation of bulk density, usually based on the SOC content. Moreover, forest soils can contain high amounts of rock fragments (skeleton), which is sometimes neglected in SOC stock assessment as the content of rock fragments is not determined in many surveys or its determination is not very accurate. The aim of this contribution is to show how big effect the rock fragments can have on the SOC stock estimation and spatial prediction in forest soils of the Czech Republic.

Data from the aggregated database of forest soils of the Czech Republic, containing standardized soil properties compiled from several national-scale soil surveys done in the years 2000-2020, amended with the rock fragment information, were used. The data are standardized to surface organic horizons (forest floor), and mineral layers 0-30 and 30-80 cm. The number of locations where the rock fragment content was determined in the layers was 3289, 3667, and 298, respectively. Quantitative sample collection of the surface organic horizons was used for the SOC stock determination in forest floor. Bulk density in mineral soil horizons was estimated using ICP Forest guidelines. The results of SOC stock estimation was calculated with and without considering the rock fragments and the difference was assessed. It was shown that this difference can account for as much as 268 g/m2 in forest floor, the highest difference was 22.2%. In the surface mineral layer, mean difference was 4.6 kg/m2 and 28.4%, the maximum difference was 20.8 kg/m2, representing 83.3%. The effect of rock fragments on SOC stock estimation was even bigger in the deeper mineral layer 30-80 cm. The effect of rock fragments also generally increased with increasing altitudes. These results show how the reliability of SOC stock data decreases if the rock fragments are not considered.

Unfortunately, the rock fragment information is available only on a part of the locations (less than half in case of forest floor and mineral topsoil, while only about 13% in case of mineral subsoil). For the spatial prediction of SOC stocks, the rock fragments were therefore first predicted for all locations using digital soil mapping methods (namely random forests) and environmental covariates. These rock fragments predictions were then considered in SOC stock predictions. The resulting maps of SOC stock predictions with and without consideration of rock fragments are compared.

ACKNOWLEDGEMENTS

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GT 01 - 263 - F + P

SALT-AFFECTED, GYPSUM, AND CARBONATE RICH SOILS UNDER THE COMMON AGRICULTURAL POLICY AND NEW IRRIGATION IN THE CENTRAL EBRO BASIN

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Inland soil salinity occurs in the Central Ebro Basin (CEB), Spain, together with gypseous soils, uncommon in Europe. Both characteristics happen in Monegros area, in the CEB, where life-threatening soils share biodiversity conservation and rainfed winter cereal. We aim to highlight the soil features governing the soil behaviour under the imminent transformation into irrigation.

We opened 17 pits in 11 plots of barley or wheat, guided by a detailed geomorphological map. The pedons were described and sampled to determine soil salinity of the saturated paste extract (ECe), calcium carbonate equivalent (CCE), gypsum, and organic matter concentrations.

The soils represented 3 landforms: infilled valleys, colluvial deposits, and structural surfaces. Soils were classified as Typic or Sodic Haplogypsid, Typic Torriorthent, Typic Haplocalcid and Lithic Torriorthent in the structural surfaces; Gypsic Haplosalid were also in the valleys and Xeric or Sodic Haplogypsid in colluvial deposits. The moisture regime is aridic and the temperature regime is thermic. The sequence of horizons was different in the three geomorphic units showing a limited maturity, especially in the structural surface. We reached the limestone, lutite, or gyprock (R horizon) in 9 pedons at depths ranging from 33 to 180 cm. Gypsic horizons were dominant in the three landforms, at depths from 27 to 220 cm, with crystal, vermiform, nodules, fibrous, lenticular, and flour-like gypsum accumulations. Calcic horizons were limited to the structural surface, with carbonate nodules predominant.

In general, soils were saline. Sodic soils (SAR values of 12-92) occur in the valleys, where ECe ranged from 3.4 dS/m to 40 dS/m (mean = 14 dS/m). The lower ECe values were found in the colluvial deposits and structural surface (mean = 4 dS/m). Considering the ECe for the upper 50 cm, soils were strongly saline (up to 8.4 dS/m) in the infilled valley, slightly saline (up to 3 dS/m) in the colluvial deposit and non-saline (up to 0.7 dS/m) in the structural surface. Only two pedons were non-saline along the whole profile.

Gypsum content was very variable with soil depth, regardless of landform, reaching a maximum of 95% (mean = 22%). For the upper 50 cm, the mean gypsum content is 18%. CCE reached 74% in soils of the structural surface (mean = 40%) with a high vertical variability along the soil profile. The sum of gypsum and CCE ranged from 21% to 100%. The mean OM content of Ap horizons was 1.7%, being slightly higher in the valley soils (2%).

The soil salinity and composition of the studied soils 1) evidence the extreme conditions and limitations that the rainfed crops and the protected habitats are facing in the study area and 2) warn about the constraints regarding water holding capacity, and fertilizer and nutrient uptake that will arise when implementing irrigation.

KEYWORDS

Aridity, Gypsum, Salinity.

ACKNOWLEDGEMENTS

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GT 01 - 295 - F + P

MODERNIZING DIGITAL SOIL MAP OF ESTONIA USING GEOSPATIAL AND FIELD-BASED APPROACHES WITH THE FOCUS ON ORGANIC SOILS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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An accurate soil map is a critical tool for modelling soil erosion, greenhouse gas emissions and soil organic carbon stocks and is the basis for effective agricultural management. The soil map of Estonia is based on a systematic large-scale soil cover mapping conducted between 1954 to 1990, the map was digitized in 2001 at a 1:10 000 scale. However, over 65 years of land management and the construction of drainage systems to control water regimes have had an impact on soil biogeochemical processes and, thus, on soil genesis. The most vulnerable soils for drainage are organic soils, in which reduced water levels leads to peat compaction and surface subsidence, and degradation of organic material. In addition to intensified greenhouse gas emissions and the loss of high quantities of soil organic carbon, in the most extreme cases, losing organic layer of Histosols results in a change in soil type from organic soil to mineral soil. This raises subsequent challenges, including how to accurately assess the loss of organic soil area, given the changes in the definition of Histosol over time, and discrepancies between international and national systems, as well as how degraded organic soils should be classified within these frameworks. This study presents first results of updating the existing large-scale soil map of Estonia with a specific focus on organic soils by determining the loss of area of Histosols, peat thickness and organic carbon content. Modern geospatial technologies, machine learning, fieldwork observations and lab data will be integrated to build a data cube, which will allow more timely updating of the soil map and all-inclusive data extractions for modelling tasks. In 2024, fieldwork was started and resulted in 23% of soil samples (total 667) collected from areas previously marked as Histosols on soil map not fulfilling the criteria for being Histosols currently. In addition, deep-learning was used to extract unmapped drainage ditches from the digital elevation model which revealed 25% more ditches than previously mapped. This information together with field measurements will be used to develop a model for estimating loss of organic soil area. Based on the preliminary data, it can already be estimated that approximately 9% of the area of peatlands has been lost. This study highlights the necessity of updating soil maps to reflect the dynamic nature of organic soils under changing environmental conditions.

ACKNOWLEDGEMENTS

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GT 01 -380 - F + P

UPDATING SOIL MAPPING IN MEDITERRANEAN REGIONS THROUGH LANDSCAPE UNITS AND LEGACY SOIL DATA

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Relevant and reliable soil information systems are essential for addressing global challenges and achieving the Sustainable Development Goals (SDGs). Soil maps play a central role in these systems by supporting sustainable land management and the conservation of natural resources through site-specific practices. To fulfil this function effectively, soil maps must be regularly updated and harmonised. Soil maps existing in Portugal vary widely in scale (1:25,000 vs. 1:100,000), classification systems (national vs. WRB), and survey methodologies. Therefore, national authorities decided to produce an updated digital soil map for mainland Portugal at the scale of 1:100,000 using the World Reference Base for Soil Resources (WRB). Approximately 55% of the national soil mapping has yet to be converted to this target scale and classification system. The proposed approach combines delineated landscape units (LUs) with legacy soil data and was tested in three study areas located in southern Portugal (~300,000 ha each).

The methodology included: (1) delineating climatic units based on thermal regime, lithological units grouped by the origin and silica content of the parent material, and relief units defined by slope, elevation, and curvature; (2) intersecting the climatic, lithological, and relief units to define LUs, considered homogeneous with respect to key soil-forming factors; (3) reorganising the legend of the 1:25,000-scale legacy soil map, validating soil profiles, and converting the national classification system to the WRB; (4) defining soil mapping units (SMUs) by overlaying the LUs with the legacy soil map and analysing the proportional distribution of soil types in each LU; and (5) evaluating the correspondence between SMUs and 162 reference profiles using a presence/absence scoring method, considering all WRB Reference Soil Groups that occupy more than 5% of each unit.

Across the three study areas, 125 LUs were delineated by combining three climatic classes (Littoral Warm Land, Continental Warm Land, and Continental Temperate Land), 23 lithological units, and five relief units (Plains, Undulating, Strongly Sloping, Steep, and Very Steep). Due to similarities in soil composition among some LUs, 69 SMUs were ultimately defined. The correspondence rate between SMUs and reference profiles was approximately 82.0%, with most mismatches still considered acceptable for the respective environmental context.

The present approach offers a scalable and replicable method for updating and enhancing soil information systems in Mediterranean environments. It supports the harmonisation of national soil and land suitability mapping, as well as the development of policies that promote sustainable land use. This research also facilitates alignment with the neighbouring country (Spain) and contributes to soil data interoperability at the European level.



GT 01 - 435 - F + P

SOIL FORMATION CONDITIONS, PROCESSES AND CLASSIFICATION ON THE BALTIC SEA COAST OF LATVIA

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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The research area is located on the west coast of Latvia, within the coastal lowlands along the Baltic Sea. The Jūrkalne area presents a remarkable geological record that offers unique insights into the interplay between glacial, interglacial, and paraglacial processes. It features flat topography typical of coastal lowlands. However, soil formation in coastal areas and dunes is a complex process, despite the parent material consistently being sand. These soils are unstable, and human activity significantly influences their development. This study investigates the Baltic Sea coast's complex and dynamic soil formation processes. It focuses on the morphological and physicochemical transformations of the soil, influenced by forest fires, wind erosion, possible slash-and-burn agriculture, marine aerosol input, and aeolian deposition of beach sand. Initially, soil development was characterized by podzolization, which was subsequently altered by depodzolization, as evidenced by an increase in soil pH. Aeolian activity caused the burial of the original soil, which retains morphological features typical of Podzols. However, due to its chemical properties, the soil no longer qualifies for classification as a Podzol. According to the World Reference Base 2022 [1], it is classified as an Arenosol. Several potential contributors to the observed pH increase were identified, including marine aerosol input, agricultural activity, and the chemical composition of windblown sand. Each of these factors may have contributed to the depodzolization process. However, the exact cause of the pH increase and resulting depodzolization remains uncertain. A single dominant factor might cause it, or it could have resulted from a combination of these factors. The results of this study contribute to a deeper understanding of coastal soil genesis and highlight the challenges associated with their classification, specifically, the classification framework of paleosols and uncertainties when applied to coastal soils.

KEYWORDS

Baltic Ice Lake sediments, buried soils, podzolization, depodzolization, Arenosols.

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GT 01 - 525 - F + P

EVOLUTION OF SOILS IN THE NORTHEAST CHINA BLACK SOIL REGION: EVIDENCE FROM GEOCHEMISTRY

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Understanding the controls of topography and pedogenic time on soil chemical weathering is essential for reconstructing landscape evolution and assessing long-term soil sustainability. This study investigates eight soil profiles from the black soil region of Northeast China, encompassing various landforms, soil types, and land uses. Major element concentrations, mass transfer coefficients (τ-values), weathering indices, and radiocarbon-dated soil ages were analyzed to reveal the spatial–temporal patterns of element mobility and weathering intensity.

Results show that soil profiles on the backslope and footslope exhibit higher weathering intensity than those on the summit, but are driven by different processes: in situ leaching dominates backslope, whereas the footslope profiles are characterized by material accumulation and secondary weathering. Chernozem display carbonate enrichment, weak leaching, and enriched $\delta^{13}C$ in both organic and inorganic carbon, reflecting semi-arid conditions. In contrast, forested and footslope profiles exhibit lower pH, stronger carbonate leaching, and depleted $\delta^{13}Corg$, indicating more humid and biologically active environments.

Soil age–depth relationships confirm longer pedogenic histories in black soils than in calcareous soils, with the most developed profiles found at forested and footslope. Freeze–thaw processes, slope hydrodynamics, and vegetation cover jointly contribute to vertical and spatial geochemical heterogeneity. Principal component analysis further supports the dominance of base cation loss and Al/Fe enrichment in shaping weathering gradients.

This study highlights the coupled influence of microtopography, pedogenic time, and vegetation on soil geochemical evolution in long-slope landscapes, providing quantitative insights into the mechanisms controlling element redistribution in cold-temperate agroecosystems.

ACKNOWLEDGEMENTS

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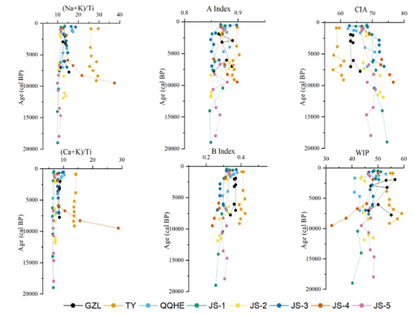
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Accumulation over time of radiocarbon dating age and weathering index



GT 01 - 11 - P

STRONG DIFFERENCES IN PEDOGENESIS ON LAVA VS. SCORIA ALONG A HYDROCLIMATIC GRADIENT ON SANTA CRUZ ISLAND/GALÁPAGOS ARCHIPELAGO (ECUADOR) – INSIGHTS FROM MICROMORPHOLOGY

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Galápagos has very diverse soil resources. In a recent study, we found vastly different pedogenic development on lava vs. scoria along a hydroclimatic gradient on Santa Cruz Island (800 m elevation difference; precipitation ranging from 100 to 1600 mm a-1). On the more porous scoria deposits, soils consistently developed towards deeper and more weathered profiles with increasing humidity, while on the lavas, soil development did not follow a consistent elevational pattern. The micromorphological investigations show an increasing degree of primary mineral weathering with increasing altitude and humidity, which was more pronounced in the profiles on scoria than on lava. The greater weathering on scoria is likely due to higher inter-particle porosity and therefore larger surface area exposed to weathering. In the arid climate zone, the soil on scoria was very shallow and the primary minerals hardly weathered, whereas the soil on lava showed a greater profile thickness and a noticeable weathering of primary minerals. Unlike the relatively homogeneous scoria deposits, the lavas show irregular flow patterns with large rock outcrop sections and small depression patches, in which soils with higher available water capacity have formed. In a previous study, we also found strongly elevated phosphorus levels in these soil patches in the arid zone. Bolstered by electron microscopy and microanalyses we show evidence that these possibly originate from tortoise nesting activities. Our results point to a complex interplay of rock type, geomorphology, climate and also the activities of the Galápagos giant tortoises in shaping the soil-scape of this unique ecosystem.

ACKNOWLEDGEMENTS

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GT 01 - 167 - P

OXISOLS ASSOCIATED WITH PALEOGENE GEOMORPHOLOGICAL SURFACES IN BRAZIL: CURRENT SOILS OR RELICT PALEOSOLS?

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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In the interior of Brazil, extensive gently surfaces have been evidence of the action of (paleo)climatic events since the Paleogene, associated with the South American planation cycle. Kaolinitic-oxidic soils dominate the areas, and may present nodular horizons. The origin of these soils, particularly their relationship with the underlying rocks, is still debated, since the surfaces truncate several lithologies indiscriminately. The study analyzed an Oxisol on the northeastern edge of the Paraná River Basin Plateau to determine whether its formation occurred in situ or involved transport of materials related to the deposits of the South American paleosurface. Therefore, conventional methods were employed - morphological description, microscopy, and chemical and physical analyses. The soil presents depth of about 8 m, clayey texture, and homogeneous red color, low base saturation (30%), low silt/clay ratio (0.2), low clay activity (~3.44 cmolc/kg of clay), crystalline features of gibbsite in cavity pores, and acric character. In addition to the control section, an increase in the size of the structure, in blocks, and the presence of clay skins with at least a moderate degree of development was identified with no evidence of clay illuviation. The base of the profile presents petroplinthic levels, whose conglomeratic matrix is composed of rock fragments, ferruginous nodules, ferricretes fragments, presenting discordance with the underlying material, aeolian sandstones of the Botucatu Formation. The presence of iron-cemented horizons on well-drained surfaces is considered residual. The composition of the profile is not restricted to the surrounding rocks, but also incorporates previously weathered materials, reinforcing the polygenetic character of its evolution. Soils such as these occupy vast areas in the interior of the country, and may be considered as relict paleosols, whose characteristics may pose challenges to agricultural management due to imitations in chemical fertility.

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GT 01 - 269 - P

SOIL MINERALOGY: THE KEY TO DIFFERENTIATING SOILS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soil mineralogy influences soil cation exchange capacity, physico-chemical dispersion, slaking, and rainfall-induced structural seal formation. However, the overwhelming majority of soil-related studies focus on the physico-chemical and increasingly microbial properties of soil in differentiating soil types and their responses to biotic and abiotic stresses ignoring their mineralogy. In this research work, the importance of soil mineralogy in differentiating soils is established using soil samples from the United Kingdom (UK), France, and Brazil. These samples were prepared and analysed for their physico-chemical and mineralogical composition using standard analytical procedures. Quartz was the main tectosilicate in all the soil samples. The mixed-layer illite/smectite type clay was the principal class of phyllosilicate found in all but one of the UK and French samples while kaolinite was the dominant phyllosilicate mineral in all the Brazilian soil samples. The physico-chemical analysis results showed the different textural classes of the tested soils with the highest clay content recorded in the Cresneuil-France (55% w/w) and Westbury 2-Wiltshire (42.5% w/w) soil samples which accounted for their high cation exchange capacity values and high concentration of exchangeable cations. Although all the tested soil samples are non-sodic, evaluation of their exchangeable magnesium percentage (EMP) suggest that two of the Brazilian soil samples (S23 and S24) with EMP > 25% have an increased risk of soil degradation and poor crop yield. Based solely on standard physico-chemical analysis, the dendogram and constellation plots grouped the Brazilian and UK soils in the same cluster. The addition of the mineralogy results facilitates the differentiation of the Brazilian soils, which were distinguished from other (UK and French) soil samples by principal component analysis. This distinction is primarily driven by the unique concentrations of kaolinite, gibbsite, and goethite in the Brazilian soils, underscoring the mineralogical variability across the sampled soil groups. Establishing the importance of soil mineralogy in differentiating soils. Reliance on physico-chemical analysis alone, as practised in many soil studies, does not provide sufficient information on soil properties for optimum agricultural, environmental, and land management.

KEYWORDS

Agriculture, Cation exchange capacity, Clay, Environmental management, Multivariate analysis, Physico-chemical properties, Soil mineralogy, Soil science

GT 01 - 434 - P

COMPARISON OF WRB AND U.S. SALT-AFFECTED SOIL CLASSIFICATION THROUGH RECLAIMED LAND SALINE SOIL INVESTIGATION

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 09. SOIL HEALTH

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Globally, the classification of salt-affected soils has primarily focused on soils in arid and semi-arid regions. The World Reference Base for Soil Resources (WRB), one of the most widely adopted soil classification systems, categorizes salt-affected soils under “Solonchaks,” which are characterized by a high concentration of soluble salts. For a soil to be classified as Solonchaks, three conditions must be satisfied:

1. A salic horizon must begin within 50 cm from the soil surface.
2. A thionic horizon must not begin within 50 cm from the soil surface.
3. The soil must not be permanently submerged or located below the tidal water level.

A salic horizon is defined by the following: the saturated extract pH at 25 °C must be ≥8.5; the electrical conductivity of the saturated extract (ECe) must be ≥8 dS m^{-1}, and the product of ECe and horizon thickness must be ≥240; or the ECe must be ≥15 dS m^{-1} and the product of ECe and thickness ≥450.

In contrast, the U.S. Salinity Laboratory classifies salt-affected soils as saline, sodic, or saline-sodic based on parameters such as ECe, pH, SAR (sodium adsorption ratio), and ESP (exchangeable sodium percentage), as detailed in Table 1.

However, South Korea’s salt-affected soils have mainly developed through land reclamation rather than from arid conditions, and relevant classification standards remain underdeveloped. This study aims to classify salt-affected soils in Korean reclaimed lands using both the WRB and the U.S. Salinity Laboratory systems, identify limitations of current classification methods, and propose criteria better suited to Korean soil conditions.

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Table 1. US Salinity Laboratory Staff Classification

Classification	Electrical Conductivity (mmohs/cm)	Soil pH	Exchangeable soudium %	Soil Physical Condition
Saline soil	>4.0	<8.5	<15	Normal
Sodic soil	<4.0	>8.5	>15	Poor
Saline-Sodic soil	>4.0	<8.5	>15	Normal

>=greater than, <=less than



GT 01 - 488 - P

RARE EARTH ELEMENT (REE) BEHAVIOR IN BAUXITIC SOILS WITH OVERLAPPING CYCLES: INSIGHTS FROM THE SOUTHERN ESPINHAÇO RANGE (BRAZIL)

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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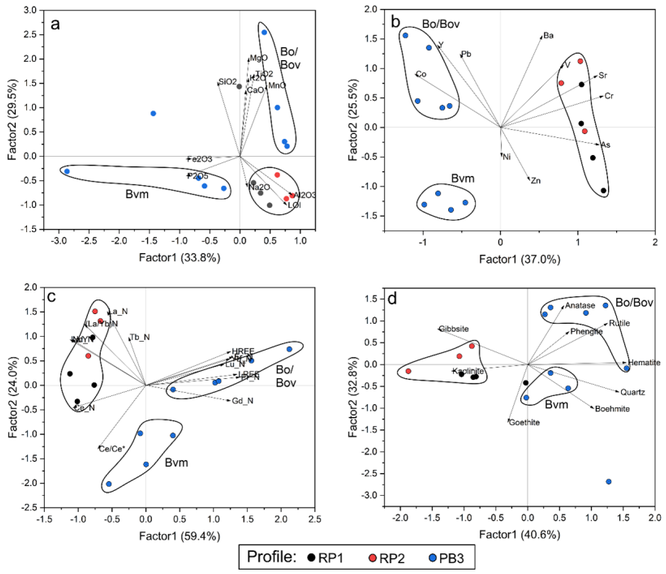
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In the Southern Espinhaço Range, southeastern Brazil, significant occurrences of Pisoplinthic Plinthosols and Nudipetric Plinthosols, alongside massive quartzites, are responsible for the current landscape configuration and the preservation of ancient surfaces. Ferruginous Plinthosols dominate the area; however, two distinct patches of bauxitic duricrusts occur, associated with different surfaces and distinct bauxitization cycles, on opposite banks of the Jequitinhonha River. Beyond their geochronological differences (Upper Miocene and Lower Pleistocene) [1], chemical and mineralogical distinctions suggest paleoenvironmental discrepancies during their evolution. To investigate this, three pedological profiles were sampled by horizon and analyzed using X-ray fluorescence (XRF), inductively coupled plasma optical emission spectrometry (ICP-OES), and X-ray diffraction (XRD). The behavior of rare earth elements (REE) was investigated using mass balance of light rare earth elements (LREE) and heavy rare earth elements (HREE), as well as Ce/Ce*, La/Y, and (La/Yb)N ratios, aiming to identify the environmental characteristics associated with the evolution of these soils. Factor analysis was also performed on the behavioral patterns of major, trace, and REE elements, as well as mineralogy, to identify potential grouping patterns. The factor analyses revealed contrasting groupings between samples from both areas (Figure 1). Furthermore, while REE suggest an acidic and reducing environment for one of the areas, the environment in the other area is not well-defined, exhibiting characteristics that are sometimes alkaline, sometimes acidic, under predominantly reducing conditions. Thus, although bauxitic duricrusts are widely used as proxies in paleoenvironmental identification due to their high stability, the superposition of bauxitization cycles makes bauxitic systems complex, adding and/or obliterating geochemical characteristics, and consequently hindering paleoenvironmental interpretation.

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GT 01 - 580 - P

PHYSICO-CHEMICAL AND MINERALOGICAL CHARACTERIZATION OF A SOIL TOPOSEQUENCE ON ISLA SANTA CRUZ ISLAND (GALÁPAGOS).

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soils in the Galápagos Islands exhibit strong variability due to the archipelago's unique volcanic origins and diverse microclimates. However, systematic studies investigating how elevation and climate gradients influence soil development on Isla Santa Cruz remain limited. This study aims to fill that gap by characterizing the physico-chemical and mineralogical properties of soils along a south-north toposequence on the island and by confirming the presence of andic soil properties in the higher-altitude zones (>300 m a.m.s.l.). Soil samples were collected from seven sites along an elevational gradient ranging from 40 to 430 m. Analyses included particle-size distribution, organic carbon content, cation exchange capacity (CEC), pH, phosphorus retention, and mineralogical composition of the fine earth (<2 mm) and silt fractions using X-ray diffraction and selective dissolution techniques. The results show considerable variability in soil properties across the toposequence. Soils exhibit textures ranging from sandy to clayey, organic carbon content from 0.3 to 16.1%, and CEC values from 28.3 to 100.5 cmol(+)/kg. pH values range from acidic (4.3) to moderately alkaline (7.9). Indicators of andic properties — such as high P-retention (>85%), Alo + ½Feo > 2%, and low bulk density (≤0.9 Mg/m³) — are prominent in soils above 350 m. Higher-altitude soils also show an increased presence of poorly crystalline minerals such as allophane, ferrihydrite, and gibbsite, whereas lower-altitude soils (<140 m) are dominated by 1:1 phyllosilicates and smectite. Interestingly, a profile at 370 m in the island's southeast resembles lower-altitude soils, likely due to local microclimatic conditions (e.g., lower rainfall), highlighting the influence of both altitude and microclimate on pedogenesis. Iron oxides are abundant throughout the sequence. These findings underscore the role of climate as the primary driver of soil formation on Santa Cruz Island, with secondary contributions from parent material and vegetation.



GT 01 - 625 - P

SAPROLITES IN CENTRAL EUROPE - A STILL IMPERFECTLY RECOGNIZED PHENOMENON FOR SOIL FORMATION, EVOLUTION AND LAND USE

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Saprolites are a globally widespread phenomenon as a product of long periods of tectonic stability and long-time weathering. The intensive biochemical weathering decomposes the bedrock to depths of several decameters. Bedrock becomes grus. Characteristic new formations like secondary clay minerals occur in the course of the transformation of the primary minerals. On the one hand, saprolites are depleted of easily transportable macronutrients, on the other hand they have an excellent influence on the physical properties of the soil. The character of saprolites is highly dependent on the parent rock. In Central Europe, saprolites of different petrography are found in all uplift plateaus of the Earth's history, whereby the Variscan areas such as the Rhenish Shield, Harz, Saxothuringian and Moldanubian Massif are the main areas of distribution. Saprolite dominated soilscapes offer many advantages, not least in connection with the loess loams of the last glacial periods that were formed from the saprolites themselves, ranging from soil fertility to flood protection. The contribution focuses on examples from the Bavarian Forest in SE Bavaria/Germany. It is part of the interdisciplinary joint project Landscapes under Climate Change BLIK.

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GT 01 - 634 - P

INFLUENCE OF ORGANIC AMENDMENTS ON GENES RELATED TO POLYSACCHARIDE PRODUCTION AND SOIL STRUCTURAL STABILITY IN RESTORED TECHNOSOLS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The addition of organic amendments in mine-affected soils to create "Technosols" is a key factor in recovering soil cover in quarries of arid and semi-arid regions, together with an opportunity to recycle organic waste. These inputs could improve soil aggregation and structure, increasing soil resilience and promoting long-term recovery of soil ecological functions. However, little is known about how different organic residues influence bacterial communities involved in exopolysaccharide (EPS) and liposaccharide (LPS) production. This study used an approach based on shotgun metagenomic high-throughput sequencing (MGS) of microbial DNA extracted from 5 years old technosols in a semiarid limestone quarry in the Sierra de Gádor (Almería, SE Spain), aiming to assess the abundance of genes involved in EPS and LPS production. Technosols were amended with two vegetable composts from garden clippings and greenhouse-horticultural waste, and sewage sludge. Each type of amendment was applied to the top 20 cm of 10x5 m plots (3 replicates per treatment), establishing 3 unamended plots as controls. Sequencing was carried out on an Illumina platform, and the results were analyzed using a customized Kraken2+MMseqs2 pipeline. Aggregate stability was assessed by wet sieving, revealing a 25% increase in amended technosols compared to controls. This improvement was associated with a higher abundance of genes related to EPS and LPS synthesis. Amended and control technosols shared 21 of the 46 genes associated with EPS and LPS metabolism. A total of 203 bacterial genera were identified as potential producers of cementing substances, however only ~8% of the potentially EPS-producing genera were common to all technosols. Among the shared bacterial genera Pseudomonas and Sphingomonas, carrying the genes as wza and lptG, respectively, were assigned to the biosynthesis of EPS and LPS. Notably, several taxa linked to polysaccharide production were unique to specific amendments. In technosols amended with sewage sludge (representing ~25% of the total genera), exclusive genera such as Nitrospira were identified, associated with the wza gene. Those amended with garden waste (~22%) featured unique genera potentially harboring lptB. Greenhouse waste amendments (~11%) revealed exclusive taxa, including Rhizobium, carrying lptF. In contrast, control soils exhibited ~7% unique taxa, such as Halomonas, linked to kpsT. The results suggest that different organic amendments promote specific bacterial communities related to soil aggregate stability cementitious compounds such as EPS and LPS. This highlights the importance of the type of the organic material employed in soil restoration in semi-arid regions.

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GT 01 - 636 - P

MECHANISMS OF ORGANO-MINERAL AGGREGATION IN AMENDED QUARRY SOILS UNDER SIMULATED CLIMATE SCENARIOS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Open-pit mining severely alters soil structure, compromising its ecological functionality and hindering its natural recovery. In semi-arid regions, organic amendments are used for restoration, but climate change may affect their ability to promote stable aggregates. This study assesses how three organic amendments (garden waste compost (CG), greenhouses horticultural compos (CC), and stabilized sewage sludge (SS)) influence organo-mineral aggregation under simulated future climate conditions. Restoration was carried out 5 years ago in a limestone quarry in Almeria (SE Spain), using 50 m² plots amended and planted with Stipa tenacissima (3 replicates/ treatment). One year of induced warming was later simulated via open-top chambers (OTC). Soils were analyzed for water-stable aggregate distribution (0–2, 2–20, 20–50 µm), total organic carbon, enzyme activities and 2-20 µm microstructures (Transmission Electron Microscope, TEM). Total organic carbon was higher in without OTC (-WC) conditions. This reduction in carbon under OTC conditions could be related to warming-induced shifts in microbial mineralization. Although fewer microorganisms were observed under OTC (-C) conditions, heating favored dehydrogenase and β-glucosidase activities in SS and CC, while urease and phosphatase activities decreased. For both soils amended with plant compost, these enzymatic changes were accompanied by a decrease in the formation of 2-20 µm organo-mineral aggregates under OTC conditions compared to soils -WC. Specifically, in the 2–20 µm fractions, plant-based amendments formed heterogeneous aggregates composed of plant residues and bacterial exopolymers, while SS amendments were dominated by microbial-derived organic matter, including bacteria and fungi. Colloidal organic matter, although not directly observed, likely plays a role in aggregation by retaining mineral particles within 2-20 µm fractions rather than allowing them to disperse into fine fractions. Notably, SS-WC showed higher dispersion of 0–2 µm clay particles, potentially due to non-aggregating organic matter or fractionation artefacts. Overall, OTC conditions reduced microaggregation in soils amended with plant composts but had limited effects on SS, although favored changes in microbial activities. These results highlight the influence of organic amendment type on aggregate stability, the sensitivity of organic matter to mineralization and limitation of nutrient cycling in warming scenarios. Future research should focus on the balance between recalcitrant and labile organic matter in amendments and integrate microbiological analyses to understand better microbial-driven aggregate dynamics.

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GT 01 - 642 - P

SOIL MAPPING IN ALPINE PASTURES: CONTRIBUTION OF ENVIRONMENTAL AND GRAZING COVARIATE GROUPS

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 09. SOIL HEALTH

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Alpine pastures are highly heterogeneous ecosystems, with the spatial variability of soil types and characteristics being influenced by factors such as parent material, topography, vegetation, land use, and pasture management. This study focuses on producing taxonomic soil maps of alpine pastures used for grazing dairy cattle in the Italian Central Alps. Two alpine pastures with contrasting characteristics were selected: one on acidic lithologies and the other on both acidic and carbonate rocks. The two pastures differ in terms of their geological and geomorphological contexts, vegetation types, and land use (pasture only in one, and pasture, woodland, and ski slopes in the other). Grazing activity is also expected to influence soil characteristics both mechanically, through trampling and compaction, and chemically, via nutrient deposition from dung and urine.

Around 300 soil samples were collected to enable classification of the main soil types (WRB, 2022). The most prevalent soil types were Leptosols, Regosols, Umbrisols, Cambisols, Podzols and Histosols. The spatial distribution of these soils was modelled using a series of covariates, which can be categorised into five groups: (a) lithological classes derived from a detailed geological map; (b) topographical and geomorphometric indices derived from high-resolution digital terrain models (DTMs); (c) vegetation indices calculated from Sentinel-2 imagery; (d) land-use classes derived from a land-use map of Lombardy and orthophotos; and (e) dairy cattle grazing intensity, calculated from data obtained using GPS trackers and activity sensors during the grazing season.

Digital soil mapping techniques were employed with this set of covariates, and their individual contributions to the accuracy of soil type and property predictions were assessed.

These results provide valuable insights into the effective mapping of soils in alpine landscapes. They offer useful information for land managers and other stakeholders involved in pasture management, particularly in the context of ongoing climate and land use change.



GT 01 - 790 - P

TRANSLATING SOIL CLASSIFICATION DIAGNOSTICS INTO PRACTICAL KNOWLEDGE FOR PRECISION FARMING

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Precision agriculture (PA) relies heavily on detailed, accurate, and site-specific data to optimize resource use and increase sustainability. While recent advancements in survey technologies have significantly accelerated data collection, the quality and interpretability of the collected soil data remain a challenge. This study addresses the gap between rapid data acquisition and effective decision-making by focusing on the integration of soil classification diagnostics into PA systems.

Key diagnostic units relevant under Hungarian soil and climatic conditions were identified and mapped across pilot sites exhibiting diverse environmental settings. These sites were extensively characterized using a combination of traditional soil surveys, proximal soil sensing, UAV-based imaging, yield mapping, and high-resolution elevation modeling.

The resulting diagnostic maps provide a practical framework for translating complex pedological information into actionable insights for farmers. By delivering this information in an accessible format, the system empowers end-users—particularly farmers—with a deeper understanding of their soil's properties and limitations, supporting more informed management decisions in precision agriculture.

GT 01 - 800 - P

NEARLY EXTINCT SOILS OF WESTERN COAST OF LATVIA

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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The aim of this research is to study and preserve information about the properties of disappearing soils. The study site is located on the western coast of Latvia on the edge of a steep bank, or on the seashore near Jūrkalne. The Jūrkalne steep bank has eroded by 60-70 m inland over the last 80-90 years, which could be due to the errors in the construction of port infrastructure and climate change. The erosion rate is affected not only by sea winds and winter storms, but also by increased precipitation in summer, which causes landslides. Eight soil profiles were investigated and samples were collected for further study on June 10 and 11, 2024. The collected information on the chemical and physical properties of the soils according to the World Reference Base for Soil Resources 2022 resulted in the following soil names:

1. Eutric Arenosol (Nechic) (N56°97'829''; E21°34'216'')
2. Calcaric Albic Mollic Planosol (Amphisiltic, Geric, Humic, Katoclayic, Polyarenic) (N56°97'865''; E21°34'221'')
3. Calcaric Skeletic Panthofluvic, Tidalic Fluvisol (Arenic, Oxyaquic, Protokalaic, Lignic) (N56°97'959''; E21°34'490'')
4. Calcic Planosol (Anoerenic, Columnic, Endoclayic, Geric, Humic) (N56°97'914''; E21°34'396'')
5. Gleyic Urbic Technosol (Calcaric, Chernic, Endoclayic, Epiarenic, Eutric, Geoabruptic, Humic) (N56°99'355''; E21°36'359'')
6. Endocalcaric Chernic Phaeozem (Arenic, Abruptic, Humic, Bathyclayic) (N56°99'364''; E21°36'377'')
7. Petric Plinthosol (Aeoli-novic, Arenic, Eutric, Ochric) (N57°01'680''; E21°38'433'')
8. Petrocalcic Someric Kastanozem (Anoloamic, Endoarenic, Humic) (N57°00'692''; E21°37'848'')

The data obtained exhibits: soils that have not been affected by the deposition of new material brought by sea wind or tides are among the most fertile soils in Latvia. This can be concluded by observing the data on the thick horizons, rich in humus and the amount of calcium carbonate found in the deeper horizons of the soil.

The collected data provides an understanding of geological and pedological processes on the western coast of Latvia and could potentially stimulate the government and other stakeholders to understand and take active action to reduce and stop the destruction of the steep bank of Jūrkalne.

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GT 01 - 901 - P

WRB CLASSIFICATION OF SOME TYPICAL CLAY SOILS ALONG THE TWO MAJOR CROATIAN RIVERS – VERTISOLS OR GLEYSOLS?

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soils rich in swelling clays pose significant challenges for various engineering and agricultural applications. This is primarily due to their unfavorable consistence. In many classification systems, including the World Reference Base (WRB) and the Croatian soil classification system, soils containing at least 30% clay and exhibiting distinct pedoturbation (vertic) properties — such as cracks or slickensides — are classified as Vertisols. In Croatia, most soils rich in swelling clays are hydromorphic and found along river valleys, largely correlating with the WRB group of Gleysols (soils saturated with groundwater long enough to develop reducing conditions and gleyic properties). However, due to the seasonality of the temperate continental climate in continental Croatia, droughts occur even in Gleysols. Consequently, some of these soils may possibly qualify also as Vertisols. This study aimed to classify four typical soil profiles formed on fluvial clay sediments along the two longest rivers in Croatia - Sava and Drava (two soil profiles were analyzed along each river, one upstream and the other downstream). Soil texture ranged mostly from silt clay to heavy clay. Clay content was averagely higher in the Sava profiles (58%) compared to the Drava profiles (45%), generally increasing along both rivers. Soil CEC was positively correlated with clay content ($r=0.96$, $p<0.001$) and uncorrelated with Corg content, despite its abundance (2.9-9.9%) in all four topsoils. CECclay ranged from 42.9 to 58.7 cmol/kg. The above results are attributed to smectite, as the dominant clay mineral in three profiles, and vermiculite, as the dominant clay mineral in one profile. Clay was recognized as the primary factor influencing soil plasticity, with the correlation coefficient between its content and the plasticity index of $r=0.85$ ($p<0.001$). Overall, with their plasticity index reaching up to 59%, all soils were high plastic. Their shrink-swell activity was evidenced primarily by slickensides along some aggregate surfaces. They were classified as Eutric Stagnic Gleysols (Clayic, Humic, Protovertic). As they were not dry during field survey, evidence of shrink-swell cracks was not (clearly) observable and they were not classified as Vertisols. We propose that, for the determination of vertic horizon within the WRB, plastic limits/indices (or the coefficient of linear extensibility, which is used for diagnosing the protovertic horizon) could also be utilized. This would be useful for clayey gley soils that are dry during summer periods, especially given the current shifts in global climate.

KEYWORDS

Soil plasticity, Cation exchange capacity (CEC), Soil mineralogy, Gleysols, Vertisols

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GT 01 - 944 - P

BASIC CHARACTERISTICS OF PALEOSOLS IN EOLIAN SANDS OF DIFFERENT GEOLOGICAL (ALPIAN AND CARPATHIAN) ORIGIN

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Paleosols are researched worldwide for their potential to reconstruct the paleoenvironmental conditions that existed when they were formed. Specifically, palaeosols are soils that were created in the past under different pedogenetic conditions than those present today. They preserve the characteristics of the pedogenetic factors and processes from that period. Paleosols developed on eolian sands of fluvial origin are particularly significant for research. Profiles were investigated at open outcrops in four locations: Đurđevac Sands, Labudovo Okno, Dubovac, and Grebenac. Đurđevac Sands is located in Croatia in the southwestern part of the Pannonian basin. Comparatively, Labudovo Okno, Dubovac, and Grebenac are situated in the Deliblato Sands protected area in Serbia, in the southeastern part of the Pannonian basin. This study enhances research on successions, focusing on the basic pedological and mineral characteristics of paleosols formed within eolian sand successions. Based on field observations, distinct horizons were identified, analysed, and sampled. The descriptions of these horizons included their colour, grain size, structure, texture, bioturbation, and the presence of charcoal, pottery and/or fossils. Laboratory methods included 14C dating, grain-size and pH analyses, distribution of the granulometric parameters (Mo, So and Sk) and their ratio (So/Sk), as well as assessments of carbonate content, soil organic matter (SOM), humus, and the bulk mineral composition of the fraction smaller than 2 mm (using X-ray diffraction, XRD). The investigated section of the Đurđevac Sands is of the Holocene and early Pleistocene age. The Deliblato Sands were formed during the Bronze Age (2.200 – 700 BC), as evidenced by pottery findings in the anthropogenic paleosoils at the Labudovo Okno and Dubovac sections. The Deliblato Sands have finer-grained materials, and the paleosoils in this region are better developed compared to others. The Deliblato Sands have finer-grained materials, and the paleosoils in this region are better developed compared to the Đurđevac Sands. At the Đurđevac Sands location, there is a significantly lower average content of carbonate and humus, while the soil organic matter (SOM) content is notably higher across all locations in the Deliblato Sands. The differences in mineral composition suggest that the materials in the two areas originate from different sources. These findings confirm substantial differences between the paleosoils formed in the Drava basin and those developed in the Tisa-Danube basin. Additionally, the mineral composition of the Dubovac profile indicates a shift in the source area of the aeolian material. The Đurđevac Sands pedosedimentary complex originates from the Drava River, which is of Alpine origin. In contrast, the Deliblato Sands are sourced from the Danube, Tisa, and/or Morava Rivers, which have Carpathian and Carpathian–Balkan (Stara Planina Mountain) origins.

ACKNOWLEDGEMENTS

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GT 01 - 989 - P

TRANSFORMATION OF LAMELLAE IN SANDY AND SILTY SOILS OF SOUTHERN POLAND

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Lamellae are defined as morphological illuvial forms occurring in soil as a series of thin layers enriched in oriented clay on mineral grains, iron and aluminum oxides, and soil organic matter. They are commonly found in soils developed from Quaternary deposits. While a relatively large number of studies have described the origin of lamellae, there is still a lack of research dedicated to their transformation.

The aim of the present research was to determine the transformation of lamellae under the influence of soil-forming processes such as podzolization and lessivage, with a focus on identifying the directions of these transformations.

The study was conducted in southern Poland on soils developed from aeolian sands, fluvioglacial sands, loess, and loess-like deposits. Soil profiles were excavated, described, and sampled, with detailed information on lamellae morphology also recorded. Selected physical and chemical properties were determined: texture via the laser diffraction method, total carbon concentration (TC) using gas chromatography, soil pH measured potentiometrically in distilled water at a 1:1 ratio, forms of iron and aluminum using flame atomic absorption spectroscopy (F-AAS), mineral composition using X-ray diffraction (XRD), and chemical composition using inductively coupled plasma mass spectrometry (ICP-MS). Undisturbed soil samples were collected for micromorphological analysis, which was carried out using both a polarizing microscope and a Hitachi S-4700 scanning electron microscope on thin sections from selected horizons.

The results indicate that lamellae undergo various types of transformation, the mechanisms and extent of which depend on their position in the soil profile, the dominant soil-forming process, and the stage of soil development. Transformations in the studied soils can be classified into two main directions: (1) degradation of lamellae and (2) enhancement of their expression (development). The degradation of lamellae is influenced by processes such as bioturbation, swelling and shrinking of soil material, eluviation, and the chemical dissolution of iron compounds.

ACKNOWLEDGEMENTS

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GT 01 - 1048 - P

MULTI-PROXY ASSESSMENT OF LATERITIC WEATHERING USING REE, PB ISOTOPES, (U-TH)/HE DATING, AND Δ13C: A CASE STUDY FROM THE CUESTA AND PAULISTA PERIPHERAL DEPRESSION, SÃO PAULO STATE, SOUTHEASTERN BRAZIL

GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Rare earth elements (REE), U, Th, Pb, and Pb isotopes are key proxies for tracing elemental mobilization during weathering and parent materials influence in lateritic profiles [1]. Iron oxides like hematite and goethite allow (U-Th)/He dating [2], and δ13C values serve as proxies of paleovegetation [3]. In southeastern Brazil, the Cuesta and the Paulista Peripheral Depression form a stepped landscape shaped by weathering of sedimentary and mafic rocks, with ferruginous duricrusts recording intense weathering and paleoclimatic influence [4]. This study assesses REE, U, Th, and Pb concentrations, Pb isotopic ratios, (U-Th)/He ages, and δ13C values in lateritic weathering profiles across these compartments. Lateritic duricrusts were composed of goethite, hematite, kaolinite, quartz, and minor magnetite. A mineralogical gradient is evident: hematite-rich duricrusts at mid-to-high elevations (Cuesta) and goethite-rich ones at lower elevations (Peripheral Depression). REE concentrations correlate more with mineralogy than with parent rock composition, with lower levels in hematite-rich duricrusts and higher in goethite-rich ones. Light REE enrichment over heavy REE is consistent across duricrusts, soils, and parent rocks, with greater mobility in soils. Pb redistribution during weathering resulted in duricrusts with intermediate isotopic signatures and soils with the most radiogenic Pb, with 207Pb/206Pb and 208Pb/206Pb ratios indicating parental inheritance. An inverse relationship between U and Pb or Th at higher elevations likely reflects mineralogical stabilization, selective adsorption, and radiogenic decay over time. δ13C values suggest C4 vegetation dominance during Late Miocene lateritic duricrust formation, with soil–duricrust variations reflecting C3 to C4 transitions and possible land use effects. (U-Th)/He dating shows that lateritic duricrusts formed diachronously over the Neogene and Quaternary, with overlapping ages pointing to multiple weathering episodes. Younger ages occur at lower elevations, while older ages are preserved at mid- to high-elevation surfaces. These results highlight the polycyclic nature of lateritization and its control by elevation, lithology, and long-term climatic and tectonic processes.

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GT 02. SOIL PHYSICAL CHEMISTRY

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 02 - 17 - O

TRACKING OF THREE-DIMENSIONAL SOIL STRUCTURE EVOLUTION UNDER TWO CONTRASTING LAND USES

GT 02. SOIL PHYSICAL CHEMISTRY / GT 04. SOIL BIOLOGY

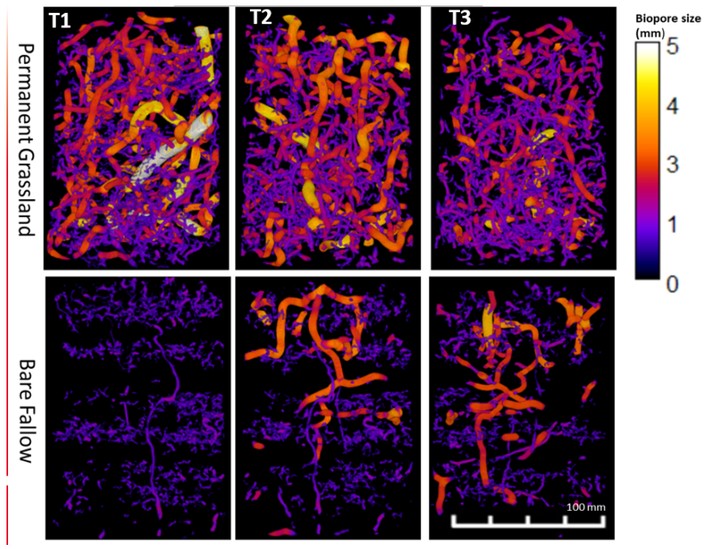
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Soil structure is a key component of soil health and sustainable land management. The intricate interactions between soil structure and soil biota underpin crucial ecosystem functions, including infiltration and nutrient cycling. To obtain a realistic perspective of soil architecture and bioturbation considering its importance, studying it in its natural state with minimal disturbance is necessary. By circumventing the disruptive effects of soil sampling and laboratory analysis, field-based monitoring provides a more realistic representation of soil conditions. Non-invasive techniques, such as X-ray computed tomography (CT), further enhance our ability to study soil structure without compromising its integrity. Therefore, this study investigates the fundamental pore-scale processes driving soil structure evolution in both biologically active and inactive environments. The focus is to study whether there is a significant difference in soil structural evolution between a biotically and abiotically active treatments. We hypothesized that biological activities significantly influence soil structure development. To test this, we compared a permanent grassland to a bare fallow treatment under field conditions. This study is in a soil structural observatory midterm experiment in Zurich, Switzerland. Disturbed soil samples were collected to a depth of 15-20cm, sieved (<5mm) and packed into soil columns (10 cm diameter and a height of 12cm) and subsequently incubated in the field and regularly scanned to monitor pore-space changes. Results indicate that both time and treatments significantly affect soil structure, as evidenced by alterations in imaged porosity, pore size distribution, critical pore diameter, thickness and connectivity ($p < 0.005$) among other descriptors. Importantly, grassland soils exhibited more rapid structural changes, highlighting the critical role of biological processes in soil structural evolution through mechanisms such as root growth and faunal activities. This research contributes to a deeper understanding of soil structure dynamics.



T1-3 Months of incubation, T2-6 Months of incubation,T3-9 Months of incubation (Evolution of Macropores)

GT 02 - 47 - O

BULK DENSITY OF SOIL: DETERMINATION BY EXPRESS METHOD ON THE TERRITORY OF LITHUANIA

GT 02. SOIL PHYSICAL CHEMISTRY / GT 09. SOIL HEALTH

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Introduction. Soil properties that can change quickly in response to natural or anthropogenic influences are considered good indicators of soil health. Among the physical indicators, bulk density was recognized as one of the ideal indicators. Measurement of soil bulk density is important for understanding the physical, chemical and biological properties of soil. Relevance should be further enhanced by the fact that: there are no detailed soil bulk density measurements in agricultural areas in Lithuania. Existing LUCAS and LULUCF network measurements are not sufficiently detailed and are not reliably linked to soil typological units and moisture regime. As regards the regional specificities of soil bulk density in Lithuania, theoretical modelling values are usually used. Accurate and quick methods for measuring soil bulk density play an important role in agricultural experimental research. According to the new method, the method provides determination of soil bulk density in the field (express method), the need arose because it is necessary to determine many samples in a short period of time.

Materials and Methods. For soil bulk density determination using different methods on the territory of Lithuania, undisturbed core samples (diameter – 46 mm, length – 51 mm) were collected 300 points at the 3–8 cm soil depth from agricultural areas (arable land and grassland). Soil volumetric water content for express method was measured three times at 5 cm soil depth for each soil core using a portable HH2 WET sensor at the same time and same site with sampling points. The weight of the samples for express method was determined by mobile scale KERN EMB 600-2 (calibrated) at the same time with sampling. The same samples using stainless rings with plastic rings (soil volume – 85 cm3) were tested in the laboratory to determine the bulk density of the soil. The cores were oven-dried at 105 degrees for 48h.

Results. To validate the new (Express) method, laboratory experiments were carried out to determine the soil density of the same samples taken in the field, and then the accuracy of the method was determined by correlation. According to the results of our research conducted on the territory of Lithuania, the new method has a high reliability in relation to the old (laboratory) method of determining soil bulk density. Express method can be used to determine many samples in a short period of time. This study will contribute to a more accurate account of SOC accumulation in Lithuanian soils and modelling of regional and local values.

ACKNOWLEDGEMENTS

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GT 02 - 105 - O

HUMIC SUBSTANCES IN MOTION: DO THEY FORM A SUPRAMOLECULE OR UNDERGO ASSOCIATIVE-DISSOCIATIVE TRANSITIONS?

GT 02. SOIL PHYSICAL CHEMISTRY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil organic matter (SOM) and humic substances (HS) play profound roles in soil functioning, fertility and health, affecting global carbon cycling. However, despite significant successes in characterizing SOM and HS, our knowledge is very limited, particularly regarding the three-dimensional structure of SOM and its components. Molecular modeling exploring fundamental physical principles could be insightful in investigating the potential organization of SOM and HS-containing systems. This work presents a molecular dynamics (MD) simulation of HS models, in the intention to shed light on the influential question of how HS are organized and whether the aggregates of HS molecules could be seen as “a stable supramolecule” or rather as undergoing a variety of associative-dissociative transitions. The answer to that question is important for understanding the size of HS, its origin, formation and degradation. The essential progress in such modeling has led to the development of Vienna Soil Organic Matter Modeler (VSOMM) [1], which provides options to model HS systematically, by considering it as a mixture of molecules, varying their size, and ionization extent, while maintaining the composition similar to that in real samples determined using 13C NMR spectroscopy. Leonardite humic acid (LHA) was explored in this study due to the earlier accumulated experience in its MD modeling and available experimental data describing the LHA dynamics in natural systems. Hence, a set of simulations of 100 ns was performed to examine LHA models, from a hydrated HS to the dissolved HS, with varying the contents of carboxylate vs carboxylic groups, and the presence of the monovalent Na+ vs the divalent bridging Ca2+. The LHA was characterized in terms of cluster formation and distances between LHA molecules as a function of their concentration, besides other properties, thus directly addressing the question: are the intermolecular forces capable of keeping HS molecules together, or do the HS undergo gradual associative-dissociative processes as a function of HS concentration? The short answer to this question is that within the 100 ns MD simulation, indeed, aggregates of LHA molecular models decompose into smaller clusters, in particular in the presence of Na+ (an expected state for commonly base-extracted soil HS) [2]. Based on these virtual experiments, it could be anticipated that the variety of associative-dissociative equilibria undergoing a gradual shift following changes in HS hydration (concentration) is a more appropriate vision of LHA than “a single stable supramolecule”. The results of the modeling are indirectly supported by the literature data on the experimental characterization of LHA in terms of size and molecular weight.

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GT 02 - 147 - O

DEVELOPING HIGH-PRECISION SOIL CEC MEASUREMENT FOR CANADIAN AND U.S. LABORATORIES: PEDOTRANSFER EQUATIONS, RAPID ROUTINES CHEMISTRY ANALYSIS, AND VIS–NIR/MIR SPECTROSCOPY

GT 02. SOIL PHYSICAL CHEMISTRY / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Cation exchange capacity (CEC) is a cornerstone indicator of soil fertility, yet routine laboratory measurement with ammonium-acetate extractions is slow, costly and rarely performed. This study benchmarks three predictive routes; (i) clay- and carbon-based pedotransfer functions (PTFs), (ii) a chemical-signature model that exploits rapid wet-chemistry tests (pHw, organic matter, Mehlich-III Ca, Mg, K, Na), and (iii) spectral-signature models that couple visible–near-infrared (Vis–NIR, 450–2 500 nm) and mid-infrared (MIR, 2 500–25 000 nm) reflectance spectra with machine learning—to deliver rapid, scalable CEC estimates for 450 soil samples from Québec, Ontario, Maine and Prince-Edward Island. Random-forest (RF), XGBoost and support-vector regression were tuned for the chemical signature; partial least-squares regression (PLSR), Cubist and convolutional neural networks (CNN) were calibrated for spectral data. Ten-fold cross-validation and metrics (R^2, RMSE, RPIQ) quantified performance. PTFs explained at most 72 % of CEC variance (RMSE = 10.5 cmol (+) kg^{-1}). Incorporating routine chemistry lifted accuracy: the RF chemical-signature model achieved R^2 = 0.83 and RMSE = 8.0 cmol (+) kg^{-1}, with organic matter the dominant predictor. Vis–NIR Cubist models, after Savitzky–Golay smoothing and SNV scatter-correction, further improved results (R^2 = 0.90; RMSE = 9.5 cmol (+) kg^{-1}). MIR outperformed all alternatives: PLSR and Cubist with first-derivative SG1–SNV preprocessing yielded R^2 = 0.97 and RMSE = 5.0 cmol (+) kg^{-1}, comfortably surpassing the FAO GLOSOLAN accuracy target. CNNs delivered comparable skill without manual preprocessing. Th e hierarchy of predictive power was MIR ≫ Vis–NIR ≫ Chemical signature ≫ PTFs. Mid-infrared spectroscopy integrated with data-driven modelling thus offers the fastest, most precise and bias-free route to routine CEC assessment, while chemical-signature models provide a practical fallback where spectroscopy is unavailable. Together, these three approaches give laboratories of every size and resource level clear pathways to achieve high-precision CEC measurements.



GT 02 - 185 - O

INFLUENCE OF PADDY RICE CULTIVATION ON CHEMICAL AND PHYSICAL PROPERTIES OF TWO CONTRASTING SOIL TYPES IN SWITZERLAND

GT 02. SOIL PHYSICAL CHEMISTRY / GT 05. SOIL HYDROLOGY & EROSION

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Recently, paddy rice cultivation has become possible north of the Alps in Switzerland. This new cultivation system has raised many questions regarding the suitability of different soil types and the practicability of crop rotation.

In this study, we focus on two contrasting soils (Gleysol and Cambisol) that differ in their soil hydraulic properties and carbon content but are both managed by the same farmer. We collected soil samples before the fields were converted to paddy rice cultivation, after the first growing season before harvest, and one year after the initial sampling to observe changes in chemical and physical soil properties.

Results suggest that both soils experienced significant deterioration in their physical properties (pore connectivity, permeability, bulk density, and porosity) in the topsoil and plow layer, even without puddling measures. However, after winter fallow, the Cambisol showed signs of structural recovery by increasing porosity and connectivity in topsoil macropores, while the Gleysol's soil structure mostly remained unchanged. Links between soil structure, aggregate stability, and carbon dynamics will be presented at the conference.

Preliminary conclusions indicate that the Gleysol is better suited for paddy rice cultivation compared to the Cambisol, as water infiltration is easily inhibited by disrupting the pore system after just one season. However, the limited recovery potential of the Gleysol's soil structure also indicates more challenging conditions if farmers want to rotate paddy rice with upland crops, making the Cambisol more suitable for different crops.

ACKNOWLEDGEMENTS

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GT 02 - 229 - O

EFFECT OF ASH FROM THE SANGAY VOLCANO ON AGRICULTURAL SOILS IN ALAUSÍ CANTON. CASE STUDY IN THE PUMALLACTA-ECUADOR PARISH

GT 02. SOIL PHYSICAL CHEMISTRY / GT 09. SOIL HEALTH

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Introduction:

Sangay volcano, one of the most active volcanoes in South America, has frequent ash emissions that affect large agricultural areas in the center of the country. The parish of Pumallacta, located in the Alausí canton (Chimborazo Province), is a strategic agricultural area with traditional farming systems (potato, corn, and beans) that are highly sensitive to ash deposition. This study evaluated the effects of Sangay ash on the properties of agricultural soil in Pumallacta.

Material and Method:

The study was carried out in the parish of Pumallacta, Alausí canton (Chimborazo, Ecuador), with predominant agricultural use (potato, maize, and broad bean). Ten representative sites affected by Sangay volcano ash (2022-2024) were selected: five with active cultivation (mainly maize and broad beans) and five without agricultural use. Soil samples were analyzed for texture (Bouyoucos), pH (1:2.5), organic matter (calcination), heavy metals (Cd, Pb) by AAS. All analyses were performed with the IBM SPSS 22 statistical software.

Results:

In the cultivated and uncultivated soil samples, cadmium (Cd) concentrations ranged from non-detectable values to 0.277 mg/kg, placing it below the limit allowed by Ecuadorian regulations which establishes 0.5 mg/kg (1). The presence of Cd in the soil can be influenced by both volcanic ash deposition, the use of phosphate fertilizers, and intensive agricultural practices. The values obtained in this study are below those reported by (2) (0.71-0.91 mg/kg), but are consistent with those of (3) who documented levels between 0.16 and 0.52 mg/kg in volcanic soils. For lead (Pb), the concentrations were lower than the national limit of 19 mg/kg (1), with values not exceeding 6.5 mg/kg. These results are also lower than those reported by (2,3). Surface Pb accumulation is conditioned by organic matter and soil acidity.

Conclusion:

The concentrations of Cd and Pb in the cultivated and uncultivated soils of Pumallacta were below the limits established by the Ecuadorian regulations, suggesting low contamination by heavy metals.

ACKNOWLEDGEMENTS

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CODE	SAMPLE	pH	CE (µS/cm)	MO (%)	Cd mg/kg	Pb mg/kg
PUM-1	Guapcas / Uncultivated	7,577	108,367	9,293	<0,25	4,530
PUM-2	Pillao/ cultivated	7,303	78,300	8,633	<0,25	<4
PUM-3	La Playa/ cultivated	8,390	77,500	5,657	<0,25	5,063
PUM-4	La Matriz/ cultivated	8,007	97,533	6,150	<0,25	<4
PUM-5	La Matriz/ Uncultivated	7,773	151,667	5,053	0,277	<4
PUM-6	Guapcas/ cultivated	7,813	50,767	5,577	<0,25	5,003
PUM-7	Pillao/ Uncultivated	8,730	108,767	3,993	<0,25	<4
PUM-8	El Piñán/ cultivated	7,947	60,533	4,210	<0,25	6,483
PUM-9	La Playa/ Uncultivated	7,790	69,900	3,907	<0,25	<4
PUM-10	El Piñán/ Uncultivated	7,207	21,933	7,977	<0,25	<4
LMS		0,329	0,003	0,014	0,016	0,299
F-ANOVA		***	***	***	***	***

*** Significant difference with 99.9% reliability



GT 02 - 233 - O

MERCURY IN THE SOIL-PLANT ECOSYSTEM OF A FOREST FROM THE UNESCO-BIOSPHERE RESERVE "AREA DE ALLARIZ" (NW IBERIAN PENINSULA).

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Mercury (Hg) is a highly toxic and persistent heavy metal catalogued as a global pollutant. Forest soils, the primary Hg reservoir in terrestrial ecosystems, receive Hg from the atmosphere by wet and dry deposition, as well as from shedding plant biomass (litterfall). Therefore, processes involving Hg transference in the soil-plant system are highly relevant in its global biogeochemical cycle.

This study quantifies the fluxes of Hg deposition through litterfall (HgLF) and the soil Hg reservoirs (HgRes) in a forest stand dominated by Quercus robur, a widespread native deciduous tree species in Europe. The stand is located in the UNESCO-Biosphere Reserve "Area de Allariz" (Galicia, NW Spain) and litterfall was collected monthly during 2023 and 2024. Moreover, samples of soil organic horizons (OL and OF+OH) and mineral soil (depths 0-5, 5-10, 10-20 and 20-40 cm) were obtained from three representative soil pits in the stand. Total Hg (THg) was determined in samples of all litterfall fractions (leaves, branches, lichens, miscellaneous, and fruits) and soil samples. Bulk density, pH, total C and N, effective cation exchange capacity and Fe and Al compounds were also determined in soil samples.

Mean THg concentration in litterfall fractions ranged from 2 to 136 µg kg-1 following a general sequence: lichens >> miscellaneous > oak leaves > fine twigs ≈ inflorescences >> fruits. Fluxes of Hg deposition (HgLF) were 23.5 and 25.7 µg·m-2·yr-1, and most of Hg deposition (71-81%) occurred during autumn (October to December). Oak leaves accounted for 68-73% of annual HgLF even though they represented 56-57% of the annual flux of total litterfall biomass, revealing their active participation in the uptake of atmospheric Hg and its subsequent transference to soil surface after shedding.

In soils, averages of THg were 47 and 104 µg kg-1 for OL and OF+OH subhorizons, respectively. In the mineral soil, THg mean values decreased with depth from 63 µg kg-1 (0-5 cm) to 21 µg kg-1 (20-40 cm). Mean soil HgRes was 12.6 mg Hg m-2 and 95.4% is in the mineral soil while the remaining 4.6% is mostly stored in the OF+OH layer (0.55 mg Hg m-2). Annual HgLF agrees with HgRes in the OL layer (28 µg m-2), but Hg stored in the OF+OH layer represents up to 22 years of HgLF. Following the same criteria, mercury accumulated in the uppermost 10 cm of the mineral soil (4.07 mg Hg m-2) stands for 165 years of the present annual HgLF. These results highlight the need to maintain forest soils healthy to preserve their function as sinks of Hg, contributing to diminish the environmental impacts of the potential mobilization of Hg associated to land use changes, wildfires and climate change.

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GT 02 - 253 - O

PREDICTING BULK DENSITY OF SOILS WITH VARYING DEGREE OF STRUCTURAL DEGRADATION USING SINGLE AND MULTI-PARAMETER BASED PEDOTRANSFER FUNCTIONS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Bulk density (BD) is a key soil property needed to for example calculate carbon stocks or predict soil hydraulic properties. However, measuring soil BD on a large scale is often labor-intensive, time-consuming and expensive. While pedotransfer functions (PTFs) have been developed to predict BD from readily-available or easy-to-determine soil properties, they are often inaccurate. One of the reasons might be that PTFs typically do not include a soil structure related predictor variable. The objective of this study was to explore whether adding an easy-to-determine variable that represents soil structure or soil strength does improve the prediction accuracy of PTFs. 252 horizons were sampled on 42 agricultural fields in Belgium that cover all major texture classes according to the Belgian texture triangle. At each field, two positions of contrasting field traffic and thus difference in soil structure and soil strength were sampled at three depths. Several quantitative soil physical properties were determined using laboratory and field-based methods, including soil organic carbon content (SOC), texture (sand, silt, and clay content), penetration resistance (PR) at field capacity and a soil structural quality score (Sq) taken from a semi-quantitative visual soil assessment (based on VESS). PTFs with both single and multiple parameters were developed using two classical regression methods (multiple linear regression MLR and generalized additive model GAM) and two machine learning methods (support vector machine SVM and k-nearest neighbours KNN). In addition to the above mentioned soil properties, soil layer (depth) was as well considered as predictor variable. The BD in the Train dataset ranged from 1.10 to 1.74 Mg m-3 with a mean value of 1.45 Mg m-3. Similarly, in the Test dataset, BD values ranged from 1.14 to 1.67 Mg m-3 with the same mean value of 1.45 Mg m-3. Overall, it was found that the KNN method generally showed a better predictive performance with the higher R2 and lower RMSE. Notably, while SVM also performed well, particularly on the Test dataset, its R2 values exceeded those of KNN in some cases. PR and Clay content were the two most important variables for predicting BD in all models, SOC the third most important, while also the VESS-based Sq score was found to be a good potential predictor for BD PTF models. Grouping the dataset based on soil structure (by using Sq) could substantially improve the predictive ability of most single parameter PTFs, in contrast with grouping based on texture that resulted in a slight improvement only. Grouping based on Sq or texture also demonstrated improvements in the performance of multi-parameter models. Among these, the KNN and SVM models showed relatively better overall performance. For example, the KNN model with f(SOC, Clay, PR) grouping by Sq achieved an overall R2 of 0.537 and RMSE of 0.057 Mg m-3 on the recombined complete dataset.



GT 02 - 376 - O

20 YEARS OF NON-INVERSION TILLAGE AND STRAW RETENTION: EFFECTS ON YIELD AND FIELD NITROGEN IN THE CENTS LTE IN DENMARK

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Non-inversion tillage and crop residue retention are key elements within Conservation Agriculture and Regenerative Agriculture, and are generally considered beneficial practices for soil health and the environmental impacts of agriculture. However, soil properties such as soil organic carbon (SOC), soil structure, microbial biomass and biodiversity, etc. develop slowly after adopting these practices, and the net effects are site, climate and crop-dependent. Therefore, effects on, e.g., crop yields, yield stability and N-leaching losses, take years to present themselves and are often difficult to detect over year-to-year, plot-to-plot and site-to-site variations.

The CENTS crop rotation and tillage long-term experiment (LTE) has investigated the effects of non-inversion tillage, post-harvest straw retention, and crop rotation diversity on grain yields, N yields and N-leaching in an arable system since 2003. Furthermore, this experiment is located in two temperate sandy loams in Denmark with contrasting textures and climatic conditions. Earlier results from CENTS have already shown that straw retention can increase soil carbon stocks and that non-inversion tillage can affect the SOC distribution across depths, but these effects are site and soil-type dependent [1].

Here, we present an analysis of 20 years of experimental results from the CENTS LTE, which include grain yields, grain protein-N contents and ceramic suction cup measurements of NO3- concentrations at 1 m depth. We apply novel statistical methods to this LTE's unique set of two-decade-long subsoil NO3- concentration time-series to disentangle the long-term trend effects of straw retention and non-inversion tillage from year and crop-related variations. Additionally, we quantify the effects of these practices on yearly N-leaching fluxes, grain yield, harvested N and N-use efficiency, as well as their interaction with varying weather. Together, these results offer a unique insight into the individual and interactive effects of tillage and straw retention on arable soils, which is relevant for agricultural systems across the temperate world.

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GT 02 - 394 - O

THE ROLE OF THE INVASIVE ACACIA DEALBATA IN SHAPING SOIL MERCURY POOLS IN NW SPAIN

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Soils are considered sinks of Hg in terrestrial ecosystems although differences due to dominant plant species are documented. Acacia dealbata is a leguminous plant species with progressive expansion in Galicia (NW Spain) and catalogued as an invasive species. Due to its high net primary productivity, it is expected A. dealbata to show great ability to accumulate Hg in its foliar biomass, as stomatal uptake is the main pathway of atmospheric Hg removal by plants. Through litterfall, Hg trapped in above-ground biomass reaches soil surface where different processes will determine concentration and pools of Hg in the soil profile.

Three soil pits were opened in six different acacia invaded sites across the province of Ourense (NW Spain). Soil organic horizon was sampled attending to the decomposition degree of plant debris (fresh–OL and transformed–OF+OH). Soil mineral samples from 0–5, 5–10, 10–20 and 20–40 cm depth were also collected. Common soil physicochemical properties analysis and total Hg contents (HgT) determination were conducted.

Similar atmospheric Hg transference through litterfall was assumed in the studied area as no statistical differences among HgT in OL subhorizons were identified (average 93 ± 16 µg kg-1). In the OF+OH layers, mean HgT increases up to 137 ± 19 µg kg^{-1}, soil Hg enrichment occurred during soil organic matter (SOM) transformation as almost 6 % of total organic carbon (C) present in OL (44 %) was lost in OF+OH. For N, similar values ($p>0.05$) among both organic layers were detected (27 ± 4 g kg-1). In the mineral soil, mean HgT decreased with depth from 62 to 38 µg kg^{-1} showing similar patterns than C (109 g kg-1 at 0–5 cm and 35 g kg-1 at 20–40 cm). Total nitrogen (N) also decreased with soil depth, though to a lesser extent. Total organic C and N contents, as SOM proxies, did not correlate with HgT in OL layers. As SOM transformation occurred, significant correlations were obtained for both HgT - C and HgT - N in all soil layers and corresponding Rho values (Spearman test) increased with depth highlighting the role of SOM in Hg retention.

Pools of C and N were 200 ± 22 and 15 ± 5 Mg ha-1 respectively, with similar contributions of organic (30 %) and mineral (70 %) layers to respective reservoirs. Deepest soil layers determined that mineral soil contribution to Hg pools reached 87 %, while most of Hg stored in organic layers was in OF+OH (12.6 %). The average of Hg reservoir in the whole soil analyzed from acacia stands reached 157 ± 35 g Hg ha-1.

Pools of Hg in acacia dominated stands are of environmental concern but also those of N and C and their narrow relation need to be considered during decision making on invasive plant species management in view of the current global changing climate scenario.

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GT 02 - 422 - O

INTERSPECIFIC CHEMICAL VARIATION OF EARTHWORM MUCUS AND ITS INFLUENCE ON SOIL PHYSICOCHEMICAL PROPERTIES

GT 02. SOIL PHYSICAL CHEMISTRY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Earthworms play a major role in promoting soil biodiversity, plant health, and overall soil quality. The various earthworm species can contribute differently to the formation of the macro- and microstructure of the soil through their feeding and burrowing activities. To facilitate their movement in soil, earthworms secrete an epidermal mucus that serves as a lubricant. This mucus is known to alter the soil physicochemical properties by the formation of organo-mineral complexes on the soil surface, but its chemical composition is so far poorly known. The objectives of this study were (i) to determine the differences in the chemical composition of earthworm epidermal mucus of four common earthworm species – Lumbricus terrestris, Aporrectodea longa, Aporrectodea caliginosa and Aporrectodea rosea – representing two ecological groups: anecic and endogeic, and (ii) to investigate how differences in mucus potentially explain its effect on soil physicochemical properties, depending on the mucus concentration. In laboratory experiments, we collected earthworm epidermal mucus and analyzed the heterogeneity of intact polysaccharides, their monosaccharide composition and the presence of aromatic groups in the mucus samples using capillary electrophoresis with UV detection, high performance liquid chromatography with UV detection and fluorescence analysis, respectively. The effects of mucus on the water repellency and water retention in soil were assessed by optical contact angle measurement and gravimetric water holding capacity analysis, respectively. Preliminary results for the chemical analysis of earthworm mucus revealed a similar composition between the four earthworm species. However, the effect of mucus in soil was found to be species-dependent, and the magnitude of the effects strongly depend on the mucus concentration. Overall, our findings contribute to a better understanding of the impact of earthworm species in soil through mucus excretion and highlight the need for further chemical characterization of earthworm mucus.

GT 02 - 472 - O

PHOSPHORUS SORPTION IN MEDITERRANEAN SOILS: A COMPARATIVE MODELLING STUDY USING LANGMUIR, FREUNDLICH, AND SIP MODELS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Understanding soil phosphorus (P) fixation for agronomic and environmental sustainability has led to the use of isotherm models [1]. In this study, three models (Freundlich, Langmuir, and Sip/Langmuir–Freundlich) were compared to describe P sorption in 47 Mediterranean soils (0–30 cm), from the Lisbon Wine Region, with contrasting characteristics.

Soils were analyzed for oxalate-extractable Al and Fe, sorption indices (PSC and PSI), SOC, pH and CEC. Adsorption assays were performed, and models performance were evaluated based on fits quality, regression assumptions, parameter significance, and predictive accuracy. Relationships between model parameters and soil properties were also examined.

All models showed acceptable fits. In 29 soils, the Sip exponent (nSip) equaled 1, simplifying it to Langmuir. Where nSip ≠ 1, Sip and Langmuir outperformed Freundlich. Langmuir showed the lowest AICc (45.4), while Sip had the lowest AIC and BIC (36.6 and 20.5). Regarding predictive accuracy, Sip had the lowest RMSE and MAE (5.06 and 4.72), followed by Langmuir and Freundlich. Normality was violated in one Langmuir fit, and a non-random pattern occurred in one Freundlich case. Freundlich showed strong residual autocorrelation (44 soils), Langmuir moderate (14), and Sip weak (1). Heteroscedasticity occurred in two Langmuir and one Sip fit. Langmuir had the highest parameter uncertainty (S: 146%, K: 164%), while Sip had more cases with non-significant parameters (5 soils).

Despite acceptable fits, Freundlich violated the assumption of residual independence, promoting biased predictions. Langmuir balanced simplicity and fit quality but had high uncertainty. While Sip showed superior accuracy but was penalized for complexity and had some non-significant parameters. Overall, Langmuir showed model stability, Sip offered better predictive performance, and Freundlich was less reliable. Parameters were consistent across models, suggesting stable estimation. P sorption was influenced by reactive components such as Alox and CEC, as well as by sorption-related indices (PSC and PSI).

Our results showed that soil surface heterogeneity enhances P retention by increasing sorption site diversity and that P affinity is greater in soils with higher pH and lower CEC, supporting previous findings that metal oxides directly influence P retention, even in calcareous soils. While precipitation with calcium is a key mechanism in calcareous soils, our results highlight that ligand exchange on variable-charge surfaces, particularly Fe-Al oxides, significantly contributes to P immobilization.

In conclusion, Langmuir and Sip described better the P sorption than Freundlich, with Sip achieving the highest predictive accuracy, appearing to be the most suitable model for Mediterranean soils.

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GT 02 - 501 - O

CHARACTERISING PEAT SOIL DIVERSITY ACROSS IRISH GRASSLANDS THROUGH PHYSICAL AND CHEMICAL INDICATORS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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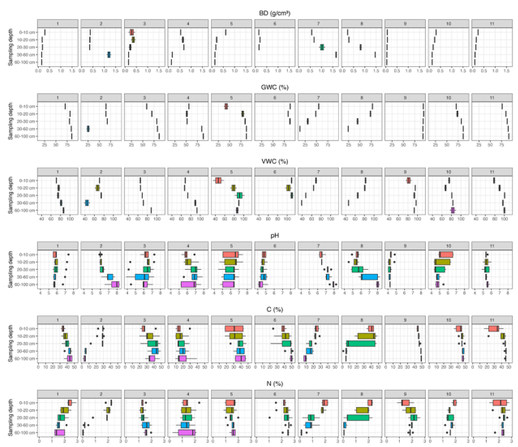
Peatlands are carbon-rich soils covering approximately 21–23% of Ireland's land area and are known for their spatial heterogeneity in physical and chemical properties. Many Irish peatlands have been modified through drainage for grassland or forestry use, and land use change has altered peat physio-chemical properties along a gradient of management and peat type, often leading to degradation which causes carbon emissions. This study examines the physical and chemical variability in peat soils under grassland across a number of agricultural peat soils (1-11 sites), representing three peat types: raised bog, blanket bog and fen. Soil samples were collected to 1 m depth using a 'W' pattern and divided into five sampling layers (0–10, 10–20, 20–30, 30–60, and 60–100 cm) along with collection of two undisturbed bulk density (BD) cores from each sampling depth. Samples were dried, sieved, and analysed for BD, gravimetric and volumetric water content (GWC, VWC), pH, total carbon, and nitrogen. Peat depths were assessed at each site and revealed that blanket bog sites had deep peats ($\bar{x}$ = 282.83) followed by fens whereas, raised bogs had shallow depths ($\bar{x}$ = 174.77).

Descriptive statistics revealed strong variability in soil characteristics by site and depth. Robust linear models were applied to each variable at each depth. BD increased with depth at degraded or mineral-influenced sites (e.g., Sites 2, 7, 8) but remained low at other sites (e.g., Sites 6, 9, 11). Sites with lower BD and higher organic matter (e.g., Sites 6 and 9) exhibited greater water retention, indicating an inverse relationship between BD and water-holding capacity. Soil pH showed wide variation, reflecting differences in organic acidity, mineral influence, and site hydrology. Elevated pH in deeper layers at Sites 2 and 7 suggests mineral interaction. Total carbon and nitrogen were highest at wet, organic-rich sites and lower at more degraded or mineral-rich locations.

This study highlights the significant spatial and vertical heterogeneity of peat soils under grassland, influenced by hydrology, land-use history, and peat type. The findings emphasise the need for site-specific peatland management in carbon accounting and emission tracking in order to reduce overall emissions from agriculture sector.

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Multi-panel boxplot distribution of soil properties (Bulk Density (BD), Gravimetric Water Content (GWC), Volumetric Water Content (VWC), pH, Total Carbon (%) and Total Nitrogen (%)), with median values, interquartile ranges (IQR), minimum and maximum whiskers (excluding outliers), and individual outliers across 11 study sites up to 1 m of soil profile.

GT 02 - 653 - F + P

WHITE LIGHT EMISSION FROM A MIXTURE OF CARBON DOTS AND GOLD NANOCLUSTERS AND ITS APPLICATION FOR OPTICAL DETECTION OF HG2+ AND FE2+ IONS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The detection of metal ions such as Hg2+ and Fe2+ using simple methods is quite important, considering their impact on humans, animals, and environment. The use of colorimetric methods for detection of such metal ions have gained importance, because of its ease of use and visual detection. Fluorescent nanomaterials show a change in the intensity of fluorescence upon the addition of a specific analyte, thus making them useful for optical sensing. However, the change in fluorescence intensity is often not detectable with naked eye and requires a fluorimeter to observe any such change. In this manuscript, we report our work on the generation of a white light emitting mixture (WLEM) by combination of three different color emitting nanomaterials. Blue and green light emitting Carbon dots, and red-light emitting Au nanoclusters were mixed in a particular ratio to obtain the white light emitting mixture. The WLEM was used for the optical detection of Hg2+ and Fe2+ ions with a moderate limit of detection. The Hg2+ ions specifically interacted with the red emitting nanoclusters, resulting in a change of color of WLEM from white to blue. On the other hand, Fe2+ interacted with all the three components in the WLEM, that resulted in the quenching of fluorescence of the WLEM. The mechanism of the quenching in both the cases has been studied and was found to be dynamic in nature. Finally, the WLEM could be coated on glass slides and used for the solid-state detection of these metal ions, indicating the potential use of the WLEM for solid-state on-site detection applications in water or soil.

KEYWORDS

Fluorescence, Carbon dots, Metal nanoclusters, W

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GT 02 - 92 - P

CHEMICAL SPECIATION AND PLANT AVAILABILITY OF LEGACY PHOSPHORUS IN PADDY RICE SOILS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Long-term excessive phosphorus (P) application has led to significant soil accumulation, contributing to environmental issues such as eutrophication in surface waters. This study evaluates whether legacy soil P can meet rice nutrient requirements and identifies the P species available for plant uptake in paddy soils. Soil samples from various regions across Taiwan were analyzed for total P concentration and other properties. X-ray absorption near-edge structure spectroscopy and sequential extraction were used to characterize P speciation and fractionation. Corresponding rice plants were analyzed for P concentrations in roots, shoots, and grains. Total soil P concentrations ranged from 326.9 to 2155.9 mg kg^{-1}, averaging 889.4 mg kg^{-1}—significantly higher than the global average of 570 mg kg^{-1}. While root P concentration correlated positively with soil total P, no significant correlation was observed for shoots and grains, indicating excessive soil P supply. The results of soil P speciation and fractionation showed that iron-bound P (Fe-P) dominated in acidic soils, while calcium-bound P (Ca-P) prevailed in alkaline soils. In high-P soils, Ca-P increased with total P in acidic conditions, whereas Fe-P increased in alkaline conditions, suggesting distinct P fixation mechanisms. The identified soil P species contributing to rice P uptake provide insights into the mechanisms governing P availability in paddy soils. These findings can help optimize P fertilization strategies, reduce fertilizer use, and mitigate legacy P accumulation and associated environmental risks.

GT 02 - 100 - P

DIFFERENTIAL SORPTION BEHAVIOUR OF COPPER IN SOME TROPICAL SOILS IN RELATION TO PARENT MATERIALS.

GT 02. SOIL PHYSICAL CHEMISTRY / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Parent materials strongly influence the nature and properties of soils. Information on the influence of parent materials on copper sorption behavior in soils is vital for copper fertilizer management and environmental conservation. A study was conducted to evaluate the copper sorption behavior of some tropical soils of southeastern Nigeria derived from different parent materials (shale, alluvium, coastal plain sands and falsebedded sandstones). Copper sorption study was done by shaking 2g soil samples with 20 mls of 0, 5,10, 20, 30, 50, 100, 200, 300 and 400 mg L-1 Cu in 0.0025 M Ca(NO3)2 solution as background electrolyte. Copper sorption data were fitted into adsorption isotherms (Langmuir and Fruendlich) to determine sorption parameters. The copper sorption parameters were correlated with selected soil properties. On sorption efficiency basis, copper sorption capacities of the soils decreased in the order shale > falsebedded sandstones > coastal plain sands > alluvium. The copper sorption parameters of the soils were strongly affected by soil properties especially pH, Ca, clay, OM and ECEC. The study showed that shale soils will require high Cu fertilization than the other soils for proper plant growth. The use of Cu adsorption isotherms as basis for Cu fertilizer management for soils of the locations studied is recommended



GT 02 - 173 - P

"INFLUENCE OF ORGANIC MULCHING PRACTICES ON SOIL QUALITY IN CITRUS ORCHARDS IN URUGUAY"

GT 02. SOIL PHYSICAL CHEMISTRY / GT 02. SOIL PHYSICAL CHEMISTRY

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Background: Organic mulches improve moisture, control weeds, and increase organic matter in citrus orchards. However, there is little information on their effect on soil bulk density and total soil porosity. Their impact on soil nutrient dynamics at different depths is also unknown.

Methods: The experiment was conducted in a mandarin orchard of the Afourer variety at the INIA experimental station in Salto Grande (Salto, Uruguay) between 2023 and 2024, covering an area of 2250 m². Treatments included a control (uncovered soil) and soil covered with cereal straw (Tritichum aestivum). At the end of each year (2023 and 2024), soil samples were collected at two different depths (0–20 cm and 20–30 cm) in each treatment. Soil bulk density, porosity, and nutrient concentration were evaluated.

Results: The results of the experiments revealed an improvement in soil bulk density in the 0 – 20 cm and 20-30 cm layers of 0.06 and 0.08 g/cm³ with mulching. This resulted in an increase in total soil porosity of 2.01 and 3.08%, respectively. Regarding soil chemical analysis, significant differences were found for P, K, Ca, Mg, and OM, especially in the 0- 20 cm layers. These differences were accentuated in both layers during the second year of sampling.

Conclusions: Mulching increased total soil porosity, improving its aeration and water retention capacity. It also increased the content of available nutrients (P, K, Ca, Mg) and organic matter, especially in the surface soil layers. The effect was accentuated from the second year of treatment onward. This management practice is promising for citrus orchards with soils compaction.

ACKNOWLEDGEMENTS

We thank INIA Uruguay, especially the Salto Grande Experimental Station, for their valuable support in carrying out this study.



Mulching in citrus orchards

GT 02 - 226 - P

CASE STUDY: USE OF RADISH (RAPHANUS SATIVUS VAR. OLEIFORMIS) AS A COVER CROPS AND ITS EFFECTS ON THE PHYSICAL QUALITY OF SOIL IN ITS FIRST YEAR OF IMPLEMENTATION.

GT 02. SOIL PHYSICAL CHEMISTRY / GT 04. SOIL BIOLOGY

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Crop rotation and cover crops are practices introduced to improve soil physical properties, such as compaction problems that hinder water movement in the soil profile, leading to oxygen depletion, root diseases, and decreased plant physiological performance. Hence, the need to verify the real impact of proposals that may impact these aspects and point toward regenerative agriculture. The objective of this study was to evaluate the effect on soil physical properties of incorporating radish as a cover crop in a wheat and pea rotation. A completely randomized experimental design was applied, with four replicates per treatment. These treatments were: T1, consisting of wheat followed by radish; T2, pea followed by radish; and two control treatments (T0), consisting of wheat stubble and pea stubble left after harvest. The comparison was made by evaluating soil physical indicators, which were integrated into the soil physical quality index. The incorporation of radish as a cover crop resulted in significantly ($P \leq 0.05$) higher hydraulic conductivity, favoring treatment T1 relative to the control T01, and lower in actual density in T1. T2 was significantly ($P \leq 0.05$) lower in organic matter but higher in usable water depth compared to its T0 counterparts.

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GT 02 - 232 - P

SHORT-TERM RESTOCK OF NUTRIENTS IN SOILS UNDER WOODY CROPS (OLIVE, GRAPEVINE, PISTACHIO) AFTER APPLICATION OF COMPOSTED FORESTRY WASTE AND PIG MANURE.

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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This study was conducted to evaluate several chemical properties of soils under different woody crops (olive, pistachio, and grapevine) after 4 different treatments: 1) control, 2) inorganic fertilizer (N-P-K), 3) compost-H (mixture of forestry wastes and pig manure) and 4) compost-L (half dose of treatment 3). Each treatment was replicated six times in olive and pistachio crops (24 plots, 9 m2) and four times in vineyard (16 stands, 5 m2). In each plot, compost and NPK were homogeneously distributed by hand and then mechanical plough mixed with the uppermost 20 cm of soil. After 0 and 6 months of the application, a representative soil sample made up with five soil subsamples (0-20 cm) of each treatment and crop type was collected and brought to the lab.

After air-dried, the soil fraction <2 mm was analyzed for soil pH in distilled water (pHw), total organic C and N contents, exchangeable base cations (Na, K, Ca and Mg displaced by NH4Cl 1M) and available P (Bray II method) and micronutrients (Fe, Mn, Cu and Zn extracted with Na2-EDTA at pH 4.65).

For any time evaluated, mean values of pHw ranged from 4.4 to 5.3 (depending on the crop), and almost no differences between control and compost-treated plots were detected. Averages of total organic C ranged from 13 to 21 g kg-1, and for all crops compost-treated plots show slightly higher values of C than control ones at both times. Total N contents (range of averages 0.9-1.4 g kg-1) are also higher in compost-treated plots than in control and NPK at both times evaluated. The sum of exchangeable base cations ranged from 3.3 to 5.3 cmolc kg-1 following the sequence of concentrations Ca>Mg>K>Na. Despite high data variability, compost-treated plots had higher levels of exchangeable Ca, Mg and K than control or NPK-treated plots, particularly after 6 months of treatment application. Mean values of available P ranged from 24 mg kg-1 in pistachio soils to 68 mg kg-1 in vineyard ones. Compared to control soils, available P tended to increase in compost-treated plots but not in NPK-treated plots. In addition, available P decreased significantly after 6 months of treatment application in pistachio and olive plots. Focusing on available micronutrients contents, the concentration sequence is Fe>Mn>Cu>Zn and only in compost treated samples was detected an increase of available Zn content.

In general, the results suggest a positive effect of compost addition on the fertility of soils under woody crops appearing as a medium-long term source of C and N, and as a short-term source of available P and exchangeable Ca and Mg. Results also suggest that compost application may offset soil nutrient losses due to yield exportation and/or leaching at the same time that favors the circular economy strategy pursuit by the European Commission.

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GT 02 - 339 - P

CLAY MINERALOGY OF SOILS IN EUROPE: IMPLICATIONS FOR SOIL HEALTH AND POLICY

GT 02. SOIL PHYSICAL CHEMISTRY / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Clay minerals are a key factor in mineral soils as they are controlling physic, chemical and biological soil properties. The aim of this research is to describe the clay minerals in soils of Europe and United Kingdom by using 388 soil samples from LUCAS 2015 survey (Fig.1). The clay fraction (<2 µm) was separated and the X-ray powder diffraction (XRPD) measurements were carried out with a Siemens D5000 diffractometer with a graphite monochromator, using CuKα radiation at 40 kV and 40 mA. The study involved the measurement of the a) air-dryed sample,b) ethyleneglycol solvated sample, and c) heat treatment at 110, 350 and 550 °C. The semiquantitative composition of <2 µm fractions was estimated by using integrated areas of 00l reflections. Short description of the clay mineralogy of all samples and semi quantitative mineral composition was performed at country level. Potential correlations between some relavant minerals detected by XRD analysis (illite, quartz, feldspars and kaonilite) were compared to some soil properties such as clay content, CEC and soil pH.

Quartz is the main stable no clay mineral and feldpars or amphiboles appear in soil mineralogies from the well known granitic shields of Scandinavian countries.On a very preliminary qualitative observation basis, central Europe (i.e. Germany, Chzec republic, Poland) and northern countries (i.e. Finland, Sweden, Latvia) have clay mineralogies more akin to have chlorite-like or vermiculitic compositions in addition to the persistent predominance of illite. These mineralogies are consistent with highly weathered, organic rich, topsoils form more cold and humid regions, very poor, on the other hand, in clay minerals, and in nutrients such as calcium, magnesium and, potassium. Kaolinite and smectite are more represented in mediterranean or southern UE countries and, in addition, iron oxyhidroxides are present and differentiate orange-brown colours of these regions. Soil samples from Denmark, Poland, Sweden, Lituania show a high content of quartz and a low content of clay and CEC lower than 15 cmol+/kg. Typical low CEC rate around 10 cmol+/kg can be found in soils with kaolinite as the predominant clay mineral. Additionally as soil pH values decreases CEC also decreases. Extremely- and alkaline soils (with pH above 7.5) with clay content above 30% show a CEC higher than 25 cmol+/kg.

Further analysis should be conducted to identify the most relevant clay minerals in soils of Europe and to find some solid trends between soil mineralogy and soil health. This study highlights the need for soil health monitoring and conservation policies that take into account regional variations in clay mineralogy and their impact on soil properties and ecosystem services. Monitoring over time can be used as soil health indicator to establish potential correlations between clay minerals and relevant soil threats such as soil degradation, soil erosion, and soil pollution.

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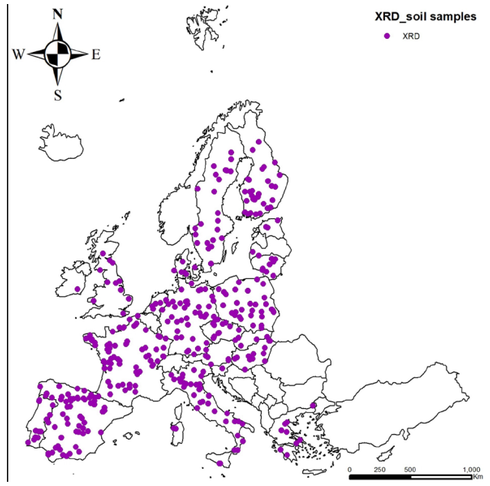


Figure 1. Distribution of soil samples for clay mineralogy analysis



GT 02 - 343 - P

ORGANIC-BASED SOIL CONDITIONER AS THE POSSIBLE WAY FOR REMEDIATION OF SOIL PROPERTIES – SIMULATION OF THE PROCESSES IN SOIL USING THE LABORATORY SEQUENTIAL LEACHING EXPERIMENTS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil organic matter (SOM) is one of the crucial components of soil responsible for its fertility, water-holding capacity and the interactions with nutrients and pollutants [1]. The main reactive part of SOM are humic substances (HS) – natural substances formed via the chemical and biological degradation of plants and animal residues. Due to the conventional agricultural practices (resulting in devastation of soil microbial life) and the increasing demands on the agronomical and agricultural production there are tendencies to improve soil properties. One of the possibilities are soil conditioners (biochar, lignite, etc.) based on organic biomass waste materials. Wise selection of appropriate soil conditioner can improve the soil properties through leaching of organic molecules and inorganic nutrients. Nutrient availability is crucial for crops, as they rely on these nutrients during their growth and development.

One way is the use of conventional soil fertilizers based on biomass residues such as compost, animal manure and mulch. But recently, the attention of a research is focused also on the application of alternative waste materials such as lignite, biochar or a mixture of individual humic fractions. The main goal of these soil supportive substances (SSS) is not only to increase soil fertility, but also to improve soil physicochemical properties and the stability of SOM [2].

Biochar and lignite belong to the group of organic-based SSS. Biochar is a promising stable carbon-rich material produced by a pyrolysis of biomass residues originating from other industries and agriculture. Lignite is the lowest rank of coal in terms of carbon and energy content which makes it less efficient for energy generation [3].

To understand processes taking place in the soil, it is necessary to have an idea of how leaching will occur and of the inorganic and organic compounds that will be transported from the used soil conditioner to the soil. One of the possibilities is the use of simple laboratory-scale sequential leaching experiments, as far as the mobility is a crucial aspect of soil science as it impacts various processes like nutrient availability to plants, contaminant transport and groundwater quality [4].

Leaching experiments as a simple laboratory method were used to determine and experimentally verify the influence of individual soil factors that could cause degradation of the biochar, lignite, and fly ash structure. Therefore, a simulation of the processes taking place in the soil environment without the presence of microorganisms was carried out and their influence on the degradation of soil support substances (biochar, lignite) was subsequently assessed. The simulation consisted of three parts. The first part focused on a simple physicochemical leaching of soluble substances, for which ultrapure distilled water and model rainwater were used. The goal was to simulate the soil environment after rain, or after watering the soil. The second part was focused on the action of low-molecular organic acids (citric acid) representing the influence of model root exudates. The third part focused on the use of hydrogen peroxide, which could simulate the soil microbial enzymatic degradation by the OH radicals. The last-mentioned reagent was also used to facilitate the progressive oxidation of biochar which would remove the labile carbon fraction and thus it might allow us to identify the changes occurring.

In order to determine how the ionic composition of the solutions changes during the experiment, the pH and conductivity of the used solutions were measured during the entire experiment according to individual replicates of samples. Both pH and conductivity measurements were made directly by placing the probe in the solution. For evaluating UV-VIS spectrometry was used along with thermogravimetry (determination of moisture, organic matter, and ash content) and elemental analysis (determination of organic carbon, hydrogen, nitrogen, sulphur, and oxygen content). Also, FTIR structural characterization (using ATR crystal) and ICP-OES analysis (determination of soluble macroelements and microelements) were used.

The results for lignite showed that the conductivity of the leachates decreases over time for all media used, but the pH of the leachates increases except for hydrogen peroxide, where the pH remains constant. Over the course of three months, the content of leached elements also decreases, where the most significant is a very rapid decrease in calcium and, in the case of the hydrogen peroxide environment, a significant decrease in microelements, which were leached only in smaller concentrations in the other environments. The conductivity of biochar leachates is similar to lignite, however, the pH did not change significantly in either environment. In the biochar leachates, the most significant concentration and decrease over time was potassium, however, a significant concentration of calcium appeared in the citric acid environment.

The leaching of elements is dependant on the conditioner used. Macroelements are leached from inorganic compounds shortly after application and subsequently stabilize. On the contrary, the organic content gradually decreases, which as a result indicates a short-term boost in terms of inorganics and a gradual release of organics, which is very advantageous and indicates the potential for further use in agriculture.

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GT 02 - 344 - P

IMPACT OF GYPSUM ON SOIL AGGREGATION, PHOSPHORUS DYNAMICS, AND BARLEY PERFORMANCE IN SOILS OF DIFFERING PH AND TEXTURE

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Gypsum ($CaSO_4 \cdot 2H_2O$), particularly phosphogypsum, is recognized for its multifunctional role in agriculture, including improving soil structure, enhancing phosphorus (P) retention, and promoting plant development. Its effectiveness is primarily associated with the soil's clay content. This study aimed to evaluate the impact of gypsum on soil aggregate stability, P leaching, and spring barley ('Laureate') growth under controlled conditions, considering soil texture and pH.

A pot experiment was conducted at the Vėžaičiai Branch of the Lithuanian Research Centre for Agriculture and Forestry. Three soil types differing in genesis and texture were studied: (1) sandy clay loam Retisol (clay: 12–14%, pH 3.9–4.3), (2) loam Luvisol (clay: 18–20%, pH 6.7–6.9), and (3) clay loam Cambisol (clay: 25–27%, pH 5.9–6.1). Topsoil (0–20 cm, 7 kg per pot) was amended with mineral fertilizers ($N_{90}P_{60}K_{60}$) and different gypsum types at 4 t ha^{-1}: (1) control (no gypsum), (2) Finnish phosphogypsum, (3) Lithuanian phosphogypsum, and (4) construction waste gypsum. The calcium content of the materials ranged from 41% to 46%. Barley was grown under artificial light and temperature until the heading stage (BBCH 49–50) over a 3.5-month period (2024-04-22 to 2024-08-08). After the harvest, soil aggregate composition and water stability were assessed using the Savinov method, and the mean weight diameter (MWD) of aggregates was calculated. Lysimeter leachate was analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), and dissolved inorganic phosphorus (DIP), using 0.45 µm filtration and ISO EN 6878:2004 standards. Plant height, root length, and biomass (above- and below-ground) were evaluated at defined growth stages.

The study indicated that gypsum application did not induce statistically significant changes in soil structure but tended to increase water-stable aggregates >0.25 mm, especially in Luvisol and Cambisol. This was also reflected in the MWD values. Phosphogypsum from Finland significantly reduced TP leaching, with the most pronounced effect observed in sandy clay loam (Retisol), where TP in leachate reached a minimum (0.114 ± 0.06 mg P L^{-1}). Lithuanian phosphogypsum and construction gypsum exhibited comparable effects. The proportion of DIP in leachate TP was highest in Luvisol (80%), followed by Cambisol (61%) and Retisol (28%). Regarding plant response, phosphogypsum notably enhanced spring barley growth on Retisol, with increased height and aboveground biomass compared to the control. Cambisol showed moderate improvement, while no significant effect was observed in Luvisol. These findings highlight the potential of gypsum, particularly phosphogypsum, in improving nutrient retention and crop development in acidic, low-clay soils.

GT 02 - 395 - P

ACIDITY CORRECTION AND CHEMICAL ALTERATIONS IN A CLAY SOIL PROFILE UNDER DIFFERENT LIMING MATERIALS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil acidity is a recurring issue in many agricultural soils worldwide, affecting approximately 40% of these areas. Acidic soils are typically characterized by high levels of exchangeable aluminum, low phosphorus availability, and low concentrations of calcium (Ca) and magnesium (Mg), which impair root development in plants. The proper selection of soil amendments—considering their reactivity, solubility, and neutralizing value—is essential for effective acidity correction. This study aimed to evaluate the effects of different acidity-correcting agents on the chemical attributes of a clayey soil profile. The experiment was conducted at USP/FZEA using 83 cm-deep drums filled with sieved clayey Oxisol. The treatments were: T1 = soil without lime (control), T2 = common lime, T3 = premium lime, T4 = oxide (full dose), T5 = oxide (1/3 of the T2 dose), T6 = oxide (1/2 of the T2 dose), T7 = magnesite, and T8 = agricultural gypsum. Amendments were incorporated at a 5 cm depth. The evaluated chemical parameters were pH, H^++Al, base saturation (V%), Ca, and Mg at soil depths of 0–10, 10–20, and 20–40 cm, at 30, 90, and 360 days after application (DAA). A randomized block design with four replicates was used. At 30 DAA, pH significantly increased in the upper soil layers in all amendment treatments, with no significant differences among materials. H^++Al was lower in the 0–10 and 10–20 cm layers, with the lowest values observed in treatments with oxides, magnesite, and gypsum. Ca levels were higher in the surface layer in treatments with common lime and oxides. Mg also showed higher concentrations in the surface layer, especially in soils treated with common lime and oxides. At 90 DAA, pH decreased with depth in all treatments except the control, which remained acidic at all depths. H^++Al was higher in the 20–40 cm layer, with lower values in treatments with oxides and magnesite. Ca and Mg followed the decreasing pattern with depth, with common lime standing out for Mg content. Base saturation (V%) was higher in the surface layers, particularly in the treatment with the highest oxide dose. At 360 DAA, pH remained higher in the 0–10 cm layer in the oxide treatments (T5 and T6), exceeding the control and the other amendments. Magnesite showed a weaker corrective effect compared to oxides. H^++Al increased with depth in all treatments. Ca was higher in the oxide treatments at all depths, especially with the highest dose, reaching 29.9 mmolc.dm^{-3} in the upper layers and 23.2 mmolc.dm^{-3} in the deepest layer. Mg was lowest in the control, while T6 provided the highest V% values across all layers. The results indicate that the application of amendments—especially higher doses of oxides—induces significant changes in the chemical properties of the soil, providing greater efficiency in acidity correction and improving Ca, Mg, and base saturation levels, particularly in the surface layers.

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GT 02 - 396 - P

SOIL PHYSICAL PROPERTIES IN UROCHLOA HYBRID CV. MULATO II PASTURES UNDER NITROGEN FERTILIZATION LEVELS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The intensification of livestock production in tropical pastures requires management practices that promote system sustainability, such as nitrogen fertilization. This practice, in addition to increasing forage productivity, can directly influence soil physical properties, which are indicators of soil structural quality. Therefore, the objective of this study was to evaluate the effects of nitrogen fertilization on Urochloa hybrid cv. Mulato II (Mulato II grass) pastures on soil bulk density, macroporosity, microporosity, and total porosity. The experiment was conducted in the field at the University of São Paulo (USP/FZEA), on a dystrophic Red Latosol. The forage species was Mulato II grass, arranged in a Randomized Complete Block Design (RCBD). Treatments consisted of four levels of nitrogen fertilization: 0, 20, 40, and 60 kg ha^{-1} of N, with four blocks. Soil bulk density, porosity, macroporosity, and microporosity were evaluated in four soil layers (0–5, 5–10, 10–15, and 15–20 cm), at two different times: at the time of forage establishment and six months after establishment. At the time of planting Mulato II grass, soil macroporosity values were below 10%, which is considered the minimum threshold for adequate root development. However, no statistically significant differences were observed between soil layers or among treatments at that stage. Six months after forage establishment, macroporosity values were higher than initial levels, particularly in the surface layer (0–5 cm) under the highest nitrogen rate, which showed a statistically significant increase. Both at planting and after six months, higher values of microporosity and total porosity were observed in the upper soil layers, regardless of the nitrogen dose applied, with statistically significant differences. Finally, soil bulk density did not vary significantly across layers or nitrogen treatments, indicating that this parameter was less sensitive to changes induced by forage cultivation and fertilization within the time frame studied. Nitrogen fertilization in Mulato II grass pastures established for six months demonstrated potential to improve soil physical properties, especially macroporosity in the surface layer (0–5 cm), when higher nitrogen rates were applied. This suggests that vegetative and root growth of the forage contributes to soil physical restructuring, favoring the formation of macropores and, consequently, improving aeration and water drainage. These findings highlight the importance of vegetative cover in enhancing soil physical quality. Overall, the results show that nitrogen fertilization, combined with the cultivation of adapted forage species, can contribute to the recovery and maintenance of soil structure in sustainable production systems, especially in regions with tropical soils of naturally low fertility.

GT 02 - 495 - P

ROLE OF NI-FE COPRECIPITATION IN NICKEL UPTAKE BY PADDY RICE

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Southern Europe soils, where most of the European rice is grown, have on average high nickel (Ni) backgrounds, mainly due to the presence of serpentinitic rocks in soil parent material. Thus, the increasing concern for consumer health is pressing rice producers to reduce Ni concentration in rice, also in view of the limit of 1.5 mg kg-1 in white rice, which will be introduced in 2026. Water management in paddy fields affects Ni availability, as flooding conditions promote the release of the Ni pool bound to Fe oxy-hydroxides, whereas drainage and oxic conditions can induce Ni immobilization via adsorption/coprecipitation with newly formed Fe oxy-hydroxides. Furthermore, CO_2 dynamics and organic acids exuded by roots strongly impact Fe-Ni interactions by influencing precipitation/dissolution and sorption/desorption equilibria in the rhizosphere: dissolved HCO3- ions can modify the oxy-hydroxide polymorph, while root exudates – especially organic acids – can mobilize Ni and Fe from the coprecipitates.

To simulate these interactions, we synthesized Fe-Ni coprecipitates obtained with oxidative Fe(II) precipitation, at different Ni/Fe molar ratios (0.002, 0.02, 0.2), in the presence and absence of bicarbonate to replicate pCO2 as a simplified model for reactions occurring in paddy soils and in rice rhizosphere. Precipitation kinetics were monitored, and the solid phases were characterized through XRD, FTIR, SEM-EDS, zeta potential, SSA and porosity, and their Fe and Ni contents were quantified by ICP-MS after acid digestion. To evaluate the release of Ni and Fe from the solids in rhizosphere-like conditions, dissolution experiments with organic acids representative of root exudates were carried out.

Our results showed that HCO3- accelerated Fe and Ni precipitation and promoted the appearance of lepidocrocite within the dominant ferrihydrite phase. Increasing Ni concentrations induced greater structural disorder in the solids and resulted in preferential Ni enrichment on the surfaces. Despite higher crystallinity, solids synthesized with HCO3- released more Ni than Fe when treated with organic acids. Ni/Fe ratios in solution exceeded those in the bulk solid, pointing to potential lability of the surface-associated Ni. This suggests that Ni incorporated within the coprecipitates may become at least partly available for plant uptake.

In paddy soils, the coprecipitation with Fe oxy-hydroxides may temporarily immobilize Ni, but redox cycling and exudate-driven dissolution can remobilize it, thus increasing its bioavailability. Since rice plants absorb more Ni when Ni/Fe ratios in soil solution are high, this study suggests a significant risk of Ni uptake from this source, which underscores the importance of managing soil redox conditions as a mitigation strategy to limit Ni uptake.



GT 02 - 558 - P

FROM CANOPY TO SOIL: LITTER DECOMPOSITION DRIVES THE FATE IN SOILS OF FIXED ATMOSPHERIC HG BY DIFFERENT PLANT SPECIES FROM THE ÁREA DE ALLARIZ BIOSPHERE RESERVE (UNESCO)

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Vegetation plays a key role in fixing and transferring atmospheric Hg to forest floor. During litter decomposition, the rate of Hg incorporation into soil depends on environmental conditions and species-specific traits. In forest patches dominated by QR - Quercus robur (broadleaf deciduous), PP - Pinus pinaster (evergreen needleleaf), and AD - Acacia dealbata (evergreen invasive species) from the Área de Allariz Biosphere Reserve (UNESCO) in Galicia (NW Spain), three simultaneous decomposition experiments using litterbags were conducted.

Fresh litter was collected and once air-dried, 180 litterbags (LBs) per species were filled with 8 g of homogenized litter. Three fenced areas per species, divided into 5 plots each, were installed and the LBs deployed over the O horizon. After 0, 1, 3, 6, 9 and 12 months, 2 LB from plot (30 LBs/species/time) were collected, air-dried, weighed, and analyzed for total Hg, Ca, Mg, and K contents. The highest mean Hg concentrations at time 0 months were in AD-LBs (54 µg kg-1) followed by QR and PP (46 and 30 µg kg-1, respectively). Similar trends (AD>QR>PP) were observed for Ca (averages 8, 7 and 2.4 ± 0.2 g kg-1) and Mg (averages 2.3, 1.1 and 0.6 g kg-1).

After 1 month, in QR and PP LBs around 95% of the initial mass remained inside while in AD it was 80%. Although less pronounced, the proportion of initial mass remaining after 12 months was 47% (AD), 56% (QR) and 62% (PP), confirming trends of decomposition rates. The concentration of the major nutrients also decreased with time. After 12 months the average concentration of Ca in LBs was 3.3, 4.2 and 3.1 g kg-1 for AD, QR and PP, respectively. Mean values for Mg were 1.0, 1.2 and 0.5 g kg-1. Twelve months after the beginning of the experiment, around 84% of the initial total Ca, Mg and K content in AD-LBs was lost, in QR it was 74% and 40% in PP. Results indicate the higher decomposition rate the higher nutrient release, as both concentration and total amount of nutrients present in LBs decreased with time.

From all species, losses of Hg in LBs were detected although to a lesser extent than for nutrients. After 12 months, 23%, 8% and only 1% of the initial amount of Hg present in respectively AD, QR and PP LBs was lost. Moreover, results showed a steady increase of Hg concentration during decomposition time. Although differences between species were noticed overtime after 12 months, mean Hg concentration in LBs was 1.6 times higher than at time 0 (AD: 88, QR: 76, and PP: 49 µg kg-1). More research is needed to understand the many complex factors that during soil organic matter transformation would determine the internal Hg accumulation but also additional Hg retention from the surrounding.

ACKNOWLEDGEMENTS

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GT 02 - 886 - P

WHITE LIGHT EMISSION FROM A MIXTURE OF CARBON DOTS AND GOLD NANOCLUSTERS AND ITS APPLICATION FOR OPTICAL DETECTION OF HG2+ AND FE2+ IONS

GT 02. SOIL PHYSICAL CHEMISTRY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The detection of metal ions such as Hg2+ and Fe2+ using simple methods is quite important, considering their impact on humans, animals, and environment. The use of colorimetric methods for detection of such metal ions have gained importance, because of its ease of use and visual detection. Fluorescent nanomaterials show a change in the intensity of fluorescence upon the addition of a specific analyte, thus making them useful for optical sensing. However, the change in fluorescence intensity is often not detectable with naked eye and requires a fluorimeter to observe any such change. In this manuscript, we report our work on the generation of a white light emitting mixture (WLEM) by combination of three different color emitting nanomaterials. Blue and green light emitting Carbon dots, and red-light emitting Au nanoclusters were mixed in a particular ratio to obtain the white light emitting mixture. The WLEM was used for the optical detection of Hg2+ and Fe2+ ions with a moderate limit of detection. The Hg2+ ions specifically interacted with the red emitting nanoclusters, resulting in a change of color of WLEM from white to blue. On the other hand, Fe2+ interacted with all the three components in the WLEM, that resulted in the quenching of fluorescence of the WLEM. The mechanism of the quenching in both the cases has been studied and was found to be dynamic in nature. Finally, the WLEM could be coated on glass slides and used for the solid-state detection of these metal ions, indicating the potential use of the WLEM for solid-state on-site detection applications in water or soil.

KEYWORDS

Fluorescence, Carbon dots, Metal nanoclusters, White light emission, Fluorescence quenching, Toxic metal ions.

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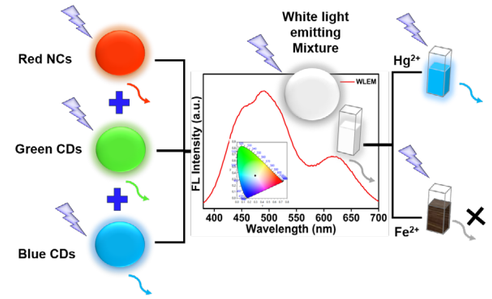
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GT 02 - 974 - P

ENHANCING SOIL PROPERTIES AND CROP PRODUCTIVITY THROUGH CROP DIVERSIFICATION: A SUSTAINABLE APPROACH

GT 02. SOIL PHYSICAL CHEMISTRY / GT 09. SOIL HEALTH

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Crop diversification in agriculture provides significant benefits for soil. It helps increase the availability of soil nutrients, maintain soil health and multifunctionality, and ultimately contributes to higher crop productivity over the long term [1]. Crop diversification is an especially valuable practice in Lithuania, where climate change has already led to a precipitation deficit of 50–80 mm during the growing season in some regions, increasing the crops' vulnerability to droughts and unpredictable temperature fluctuations. Multi–cropping systems were established at the Experimental Station of the Agriculture Academy of Vytautas Magnus University, Lithuania, on a soil classified as Planosol (Endohypogleyic-Eutric Planosol, Ple-gln-w) [2]. The experiment included single, binary, and ternary crops of maize, technical hemp, and faba bean. The aim of the study was to assess the impact of crop diversification on the physical and chemical properties of the soil and crop productivity. The experiment was conducted during the period 2020–2022. The lowest soil stability was observed when growing the single faba bean crop (31.1%), whereas the highest stability was recorded in the binary crop of technical hemp and faba bean (40.3%). Diversification of crops either had no significant effect on the total nitrogen change in the soil or, in many cases, had a negative effect due to higher biomass productivity in multi–crops. The dry biomass of the ternary crop was approximately 5 times higher compared to single crops. A comprehensive assessment showed that the cultivation of binary crops had the most positive impact on the agrophysical properties of the soil, and the ternary crop also nearly reached the evaluation threshold. Integrating multi–crops into agroecosystems can be a beneficial practice for sustainable agriculture; however, it is equally important to additionally plan the soil nutrient balance (e.g., through fertilization or green manure) to compensate for the more intensive soil nutrients uptake.

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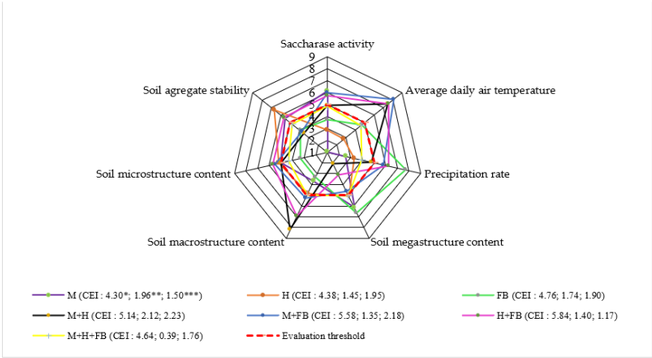


Figure 1. Comprehensive assessment of single, binary and ternary crops in 2020–2022.
Note: M—maize single crop, H—hemp single crop, FB—faba bean single crop, M+H—binary maize and hemp crop, M+FB—binary maize and faba bean crop, H+FB—binary hemp and faba bean crop, M+H+FB—ternary maize, hemp and faba bean crop. CEI–complex evaluation index, * –average of evaluation points (EPs), ** –standard deviation of EPs, *** –standard deviation of the average of the evaluation points below the evaluation threshold.

GT 02 - 1015 - P

SPATIAL VARIABILITY OF SOIL PROPERTIES AND MOISTURE REGIME ALONG VINEYARD SLOPE: A CASE STUDY IN JASTREBARSKO (CROATIA)

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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This study investigates the effect of slope position on soil properties and soil moisture regime in a vineyard on a Stagnosol in the town of Jastrebarsko (Croatia). The research focuses on spatial variability of soil properties and moisture content along different slope positions as well as between vineyard rows and inter-rows. Soil samples were collected from five distinct slope positions, ranging from the top to the bottom of the slope. Samples were analyzed to determine soil particle size distribution, pH, humus content, and bulk density. In addition, at the same slope positions, gravimetric soil moisture content was periodically measured to assess moisture dynamics along the slope and within the rows and inter-row spaces.

The results showed significant variations in soil texture, with clay and silt fractions showing clear differences along the slope ($P < 0.0001$). The upper slope positions exhibited higher clay content ($P < 0.0001$), which corresponded with greater water retention capacity ($P < 0.0001$). Soil pH and humus content also varied significantly with slope position ($P < 0.0001$), reflecting differences in organic matter accumulation and soil chemical properties affected by topography. Bulk density differences were less pronounced but statistically significant ($P < 0.05$). The comparison between vineyard rows and inter-rows showed significant differences in pH, humus, and silt content, indicating the impact of vineyard management practices on soil heterogeneity.

Soil moisture content was consistently higher in the upper slope positions, correlating with the increased clay content and associated water holding capacity. Soil moisture dynamics additionally differed between rows and inter-rows ($P < 0.05$), attributed to variations in soil cover and root activity. The findings point out that local soil properties, especially the texture and spatial arrangement of crops (vines in rows and grass-covered inter-row spaces) have a stronger effect on soil moisture retention than the slope segment itself. The study emphasizes the importance of understanding topographic and microscale soil variability for vineyard management, especially regarding irrigation planning and soil conservation. The results suggest that site-specific soil management practices could optimize water use efficiency and enhance vine growth by accounting for slope-induced variability in soil properties and moisture availability.

In conclusion, the effect of slope position on soil physical and chemical properties is significant but interacts complexly with vineyard soil management to effect the soil moisture regime. Understanding this interaction is essential for promoting sustainable viticulture on sloped landscapes and enhancing crop productivity through site-specific management practices.

KEYWORDS

Soil physical properties, Soil moisture, Stagnosol, Soils on slope, Vineyard

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GT 02 - 1064 - P

DO ALIEN WOODY SPECIES AFFECT SOIL CHEMICAL PROPERTIES DIFFERENTLY THAN NATIVE SPECIES?

GT 02. SOIL PHYSICAL CHEMISTRY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Woody species (trees and shrubs) are considered ecosystem engineers. Through litter deposition, nutrient uptake, and root exudates, they can substantially modify soil conditions, impacting both below- and above-ground biota and processes. While the ecological impact of well-known invasive alien woody species (IAWS), such as Quercus rubra or Robinia pseudoacacia, is widely recognised, the role of native expansive woody species (NEWS) remains understudied.

The study aimed to determine the impact of IAWS and NEWS on soil chemical properties in Central-European ecosystems. The study was conducted at 144 sites located in Poland, the Czech Republic, and Slovakia. Each site consisted of two plots – one with a patch dominated by an IAWS (one of the seven species: Acer negundo, Ailanthus altissima, Fraxinus pennsylvanica, Prunus cerasifera, Prunus serotina, Quercus rubra, Robinia pseudoacacia) or NEWS (one of the eight species: Acer platanoides, Cornus sanguinea, Crataegus monogyna, Fraxinus excelsior, Populus tremula, Prunus spinosa, Quercus robur, Tilia cordata), and the second one representing a control. The control plot consisted of multi-species patches of native forest or shrub vegetation located as close as possible to the plots with the dominant species. Soil samples were collected five times between autumn 2023 and autumn 2024 during the growing season. Basic chemical parameters were analysed: pH, electrical conductivity (EC), organic C content, and total N, P, K, Mg, and Ca contents.

Soils in IAWS and NEWS patches had higher pH compared to control soils. Additionally, IAWS soils were characterised by lower C, N, C/N, and EC values than control soils; such differences were not found for NEWS. The impact of IAWS and NEWS on other soil parameters was not significant. The study showed that (i) the impact of invasive woody species on soil is stronger than that of expansive natives, and (ii) there is great within-group (in both IAWS and NEWS) variability in soil properties resulting from differences in habitat preferences of the studied species.

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GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER

GT 03 - 56 - O

TOO HOT TO HANDLE: WARMING-INDUCED CHANGES IN BIOGEOCHEMISTRY OF TOPSOIL AND MAIN FOREST FORMING SPECIES IN TEMPERATE MOUNTAIN FORESTS IN CENTRAL EUROPE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Global climate change is having a negative impact on ecosystems. One such ecosystem is the temperate mountain forest, where Norway spruce is an important tree species. However, large-scale dieback of spruce trees has been observed for several decades, threatening the continuity of forest stands. To date, there is little data on the extent to which climate warming affects this process. Previous studies have focused on the biometric responses of trees to warming, but the scenario of changes in the soil is unknown. One of the major challenges facing forestry is the need to adapt forest species composition to changing site conditions. To meet this challenge, research is needed on the adaptation of species that are potential alternatives to spruce. Some prospects are seen for common beech, although there is little information on the adaptation of this species in the context of changes in the soil caused by warming.

One possible method to study the effects of climate change on soils is the in-situ simulation of future conditions. This talk will present a synthesis of two medium-term (three- and two-year) simulation experiments conducted in mountain forests of Central Europe. Both experiments employed a passive warming method using Open Top Chambers. The first experiment, conducted in a mature spruce stand, was designed to investigate the direction of biogeochemical changes in the topsoil under warming conditions. The aim of the second experiment was to investigate the biogeochemical relationship between the soil and the young generation of spruce and beech in relation to warming using 15N isotope labeling. In both experiments, the average soil temperature at a depth of 5 cm was increased by about 0.5 °C.

The studies showed significant changes in the chemical properties of the ecosystem components studied. The warmed soil was characterized by a higher content of labile forms of nitrogen, which can lead to a decrease in tree health. An increase in labile forms of carbon and an increase in topsoil pH were also observed. Young spruce trees exposed to warming were characterized by poorer growth parameters compared to the control sample. The warmed spruce trees had a lower uptake of nitrogen and macro- and micronutrients from the soil. On the other hand, young beech trees exposed to warming showed better growth compared to beech trees from the control plot, in addition to more efficient uptake of nitrogen and macro- and micronutrients from the soil.

Our research suggests that soil warming will lead to significant changes in soil chemical properties and stand species composition in Central Europe. The use of climate simulation methods in studies of soil biogeochemistry allows to identify the directions of changes in site conditions and possible consequences for vegetation.

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GT 03 - 70 - O

ASSESSING THE EFFECT OF INTRODUCING LEGUMINOUS SPECIES ON SOIL N2O EMISSIONS UNDER IRRIGATED CONDITIONS IN THE EBRO VALLEY (NE SPAIN)

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Almost 70% of global N2O emissions, a gas with a high global warming potential, are linked to the agriculture sector and mainly associated to the use of nitrogen fertilisers [1]. It is crucial to design resilient agricultural systems with lower dependencies of external inputs such as nitrogen (N) fertiliser but simultaneously decreasing soil greenhouse gas emissions (GHG). Introduction of leguminous species can provide a non-expensive source of nitrogen to the crops, reducing the higher GHG emissions related to the industrial production of synthetic nitrogen. However, their impact on soil nitrous oxide emissions under irrigated Mediterranean conditions is not well established. The objective of this study was to assess the impact of different cropping systems that included leguminous crops on N2O emissions under sprinkler irrigated conditions at the Ebro valley (NE Spain). The systems compared were: (1) monocropping (MC) long-season maize preceded with a vetch cover crop during the winter period (CC-LSM), (2) MC long-season soybean preceded with a barley cover crop during the winter period (CC-LSS), (3) double-cropping (DC) of peas with short-season maize (P-SSM), and (4) DC of barley with a short-season soybean (B-SSS). The size of the experimental plots was 18x18 m and the soil was managed by conventional tillage. The N fertiliser rates were adjusted considering the soil mineral nitrogen available before planting. Thus, a total dose of 132, 57, 237, and 223 kg N ha-1 were applied to the CC-LSM, CC-LSS, P-SSM and B-SSS, respectively. Soil N2O fluxes were periodically measured (<2 weeks) during the second rotation year, from October 2023 to October 2024 using static closed chamber technique [2]. N2O concentrations were determined by gas chromatography. Noticeable peak N2O fluxes were observed after nitrogen fertilizer applications. The accumulated emissions of N2O during the whole growing period were lower in the two MC systems of CC-LSM (1.83 kg N-N2O ha-1 year-1) and CC-LSS (2.0 kg N-N2O ha-1 year-1) compared to the two DC systems (P-SSM: 5.79 kg N-N2O ha-1 year-1; B-SSS: 5.00 kg N-N2O ha-1 year-1). No significant differences were observed in N2O emissions within MC and within DC systems. The CC-LSM presented a significant lower percentage of N2O losses relative to the nitrogen applied with the fertilizer (1.4%) compared to the CC-LSS (3.5%), but no differences were found among any other pairwise comparisons. Considering the four cropping systems, a positive, but non-lineal relationship was observed between the rate of nitrogen fertilizer and the total N2O emissions.

ACKNOWLEDGEMENTS

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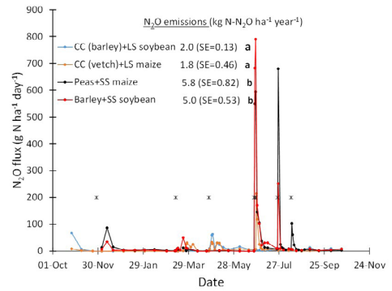


Figure 1. Evolution of daily N2O fluxes from october 2023 to October 2024 in the four cropping systems evaluated. The average cumulative N2O emissions (kg N ha-1 year-1) are presented for each system. Values followed by the same letter are not significantly different (p=0.05). The asterisks indicate the moments of nitrogen fertiliser applications.



GT 03 - 96 - O

PLANT GROWTH-PROMOTING MICROORGANISMS CAN REDUCE CO2 EMISSIONS AND ENHANCE POTATO QUALITY UNDER MEDITERRANEAN CONDITIONS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Current horticultural practices typically require high demands of fertilizers, leading to significant environmental impacts and increased production costs. Alternatives based on microbial inoculants have garnered considerable interest due to their potential to enhance soil quality while reducing external inputs and costs, all without compromising productivity. This study aimed to compare the impact of four fertilization strategies, including mineral fertilizers and microbial inoculants, on crop yield, soil fertility and functionality, and soil greenhouse gas (GHG) emissions in potato production in Southern Spain. Four treatments were tested: (i) mineral fertilizers added to meet the crop's nutritional needs (F100); (ii) a 50% reduction of the F100 rate (F50); (iii) a 50% reduction of the F100 rate combined with the application of a formulation containing nutrient-solubilizing bacteria, nitrogen-fixing bacteria, and non-mycorrhizal fungi (BAI+FU); and (iv) a 50% reduction of the F100 rate combined with a formulation of N, P and K solubilizing bacteria (BAII). Results showed that crop yield was unaffected by the different fertilization treatments. However, the mean tuber weight and firmness were significantly higher under the BAI+FU treatment, indicating improved product quality. CO2 release rates decreased by 25%, 34%, and 42% with F50, BAI+FU, and BAII treatments, respectively, compared to F100. The N2O and CH4 emissions or soil nutrient contents were not affected by treatments, except for ammonium content, which was highest under the BAI+FU treatment. Additionally, while overall soil bacterial and fungal abundance was not significantly affected, the BAI+FU treatment resulted in a higher number of nirK (denitrification) and cbbL (carbon fixation) gene copies. Therefore, combining biofertilizers with reduced chemical fertilizer rates could represent a sustainable strategy for mitigating climate change while enhancing crop quality in potato production.

ACKNOWLEDGEMENTS

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GT 03 - 145 - O

METAGENOMIC INSIGHTS INTO HOW MICROBIAL METABOLISM SHAPES ORGANIC CARBON CYCLING IN ALPINE RIPARIAN SOILS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Soils store over 90% of carbon in alpine ecosystems above the treeline. Alpine riparian zones range from wet, fine-textured floodplain soils to drier, coarser soils on adjacent hillslopes. These contrasting landscape positions form a spatial transect shaped by redox conditions. Under oxygen-limited conditions, soil organic carbon (SOC) accumulates due to thermodynamic constraints on microbial respiration. Redox contrasts therefore influence microbial respiration and SOC turnover. However, it remains unclear how microbial metabolic strategies vary across riparian gradients.

We used shotgun metagenomics to examine microbial diversity and functional potential across floodplain and hillslope soils from two catchments in the Swiss Alps. Analyses were complemented with physico-chemical characterisations. Floodplain soils stored more SOC and contained higher phenol and aromatic compound content, consistent with SOC preservation under reducing conditions and preferential respiration of bioavailable compounds. Microbial communities in floodplains exhibited greater diversity and an increased potential for anaerobic respiration pathways. Genes for nitrate, iron, and sulfate reduction were linked to Chloroflexota, Acidobacteria, and Desulfobacterota phyla, respectively. Based on NMDS correlations, electron accepting capacity, calcium, and pH were key environmental shapers of community composition. Hillslope soils, by contrast, supported less diverse communities, shaped mainly by electron donating capacity and clay content. Together, these patterns show that redox contrasts along the floodplain-hillslope transect structure microbial communities and SOC cycling.

As alpine landscapes warm, the redox contrasts that shape microbial metabolism and, in turn, carbon preservation may sharpen or collapse. Understanding how redox conditions shape microbial metabolism is therefore crucial for anticipating the future of alpine SOC.



GT 03 - 214 - O

SOIL AND ENZYME STOICHIOMETRY IN THE EXTREME ENVIRONMENT OF MEFITE D'ANSANTO (SOUTHERN ITALY)

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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With ~2000 t CO_2 per day, the Mefite site, located in the Ansanto Valley (Campania, Italy), represents the most significant natural, non-volcanic source of low-temperature, CO_2-rich gases on Earth. The area features a prominent sulfurous pond, locally referred to as "Lake Mefitis", situated at the base of a landslide deposit. This bubbling mud pool, lacking surrounding vegetation due to intense gas exposure, marks the primary degassing zone. Gas emissions emerge from multiple vents and boiling mud basins across the site, likely linked to active fault systems that have historically generated major seismic activity in the region. The chemical composition of the emitted gases is dominated by CO_2 (~98%), with minor constituents including non-atmospheric nitrogen (1.3%), hydrogen sulfide (0.33%), and methane (0.23%). Under low wind, the dense gas accumulates and flows downslope through a natural channel, forming an invisible, continuous plume that is lethal due to hypoxia and toxicity. Its impact extends up to 3 km, causing high soil acidity, oxygen depletion, and severe vegetation stress.

These unique geochemical and ecological features make the Mefite site an exceptional natural laboratory for investigating the long-term biological and physico-chemical responses of the soil system to extreme gaseous exposure. To do that, topsoil (0-10 cm) samples were collected at a distance of 30 m (zone A), 80 m (zone B) and 120 m (zone C) from the river/lake. Sediment samples were also taken from the lake. All samples were characterized for pH and electrical conductivity, major and trace elements (XRF), main mineral phases (XRD), and organic carbon, total nitrogen and sulphur content (CHNS). Enzymatic activities, including β-glucosidase (EC), urease and N-acetylglucosaminidase (EN) and phosphomonoesterase (EP), were also assessed.

Standardized major axis regression confirmed a relationship between soil EC and EN ($R2 = 0.15$, $p<0.05$) as well as between soil EC and EP ($R2 = 0.34$, $p<0.001$). The slope test performed after the regression showed a metabolic imbalance between EC and EN ($p<0.001$). The vector analysis indicated differences at metabolic level both between soil and sediment, and between soil collected at different distances. In particular, soils from zone A were characterised by a deficiency of N, which decreased with increasing distance from the lake, whereas those from zone C (pH>7) and sediments (pH~2; avg S > 50%) showed a P deficiency. Carbon use efficiency in relation to N and P confirmed this result. Although soil stoichiometric ratios C:N and C:P are not statistically different between zones, redundancy analysis identified them, together with pH (ranging from 2.5 to 7.9), as main environmental drivers of metabolic changes. Mefite is therefore confirmed as a site of extreme interest not only from the geological point of view, but also chemically and biologically.

GT 03 - 383 - O

THE FATE OF ABOVE- VS. BELOWGROUND CARBON INPUT FROM CONTRASTING COVER-CROP SPECIES IN A NORWEGIAN SOIL.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Background and aims

Cover crops are an important measure for carbon (C) sequestration in agriculture. However, little is known about the potential of cover crops to increase C under Nordic conditions and the efficiency of C storage from their above- and belowground inputs. Here, we quantify the potential contribution of different cover crops to soil organic carbon (SOC) and organic matter fractions, and study how this is affected by the origin of the C input (aboveground or belowground residues).

Methods

We conducted a 13C pulse-labelling experiment during one growing season using four cover crops adapted to Nordic conditions, with distinctive potentials for biomass production and contrasting root traits: oilseed radish (Raphanus sativus), Italian ryegrass (Lolium multiflorum), phacelia (Phacelia tanacetifolia) and summer vetch (SV, Vicia sativa). Over the next two years, we traced separately the fate in soil of root vs. shoot-C and investigated their distribution between two organic matter fractions, Particulate Organic Matter (POM) and Mineral-Associated Organic Matter (MAOM).

Results

Carbon derived from aboveground residues decayed two to three times faster as compared to belowground C. Belowground C inputs were similar among cover crops despite their contrasting root traits and differences in root biomass C. Rhizodeposited-C was consistently the largest belowground C input. Cover crop species affected the quantity of POM-C and MAOM-C, but MAOM-C was preferentially formed from belowground C, regardless of the species. At least one year, Italian ryegrass accumulated significantly more MAOM-C from belowground inputs than any other species. Belowground C input from oilseed radish persisted less in soil than that from any other species, suggesting that C input from its large tap root benefited less from stabilization mechanisms like mineral association or aggregation.

Conclusions

Belowground input from cover-crop species was preferentially stabilized in soil, especially in the form of MAOM. Cover crop species that can combine large belowground biomass production with root traits that promote physical and physico-chemical protection of OM contributed most effectively to the SOC accrual.

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GT 03 - 384 - O

FIELD MEASUREMENT OF NET C RHIZODEPOSITION OF BARLEY, SORGHUM COVER CROP AND PERENNIAL HERBACEOUS ROWS OF A MEDITERRANEAN AGROFORESTRY SYSTEM

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Increasing soil carbon (C) sequestration in diversified agroecosystem was identified as a way to achieve climate neutrality. Although less studied than aerial residues, belowground plant inputs represent a major source of soil organic carbon (SOC). Rhizodeposition represent an important process by which living roots released C in soil. However, there is a real lack of quantification under field conditions, partly due to methodological difficulties. This statement is especially true under diversified agroecosystems such as alley cropping agroforestry. These systems combine tree lines and their perennial understory vegetation strip (UVS) with annual crops cultivated in the inter-rows. This involves a high spatial heterogeneity of rooting systems with deeper rooting and different root traits expected for perennials. However, the consequences of such rooting differences on rhizodeposition flux remain poorly studied especially in subsoil (below 30 cm depth) while C have longer residence time there.

In this study, performed within the EJPSoil MIXROOT-C project, we conducted an in-situ measurement of net C rhizodeposition (gross rhizodeposition – loss by mineralization) of contrasting herbaceous vegetations, in a Mediterranean alley cropping agroforestry system. Our objectives were to investigate the three vegetation covers of the system (a barley crop, a sorghum cover crop and the perennial UVS) and the vertical (topsoil vs subsoil) distribution of their net C rhizodeposition. To do so, plants were labelled in situ twice a week with 13CO2 pulse during the full growing period and roots and soils collected up to 50 cm depth. Then, 13C excess in shoot, root and soil samples was used to calculate the net rhizodeposition and to trace C fate in organic matter fractions (Mineral-associated and particulate organic matter) and microbial groups (PLFA-SIP) at 3 soil depths (0-20, 20-30 and 30-50 cm) for barley, UVS and Sorghum. We showed that the net C input from rhizodeposition at the end of the growing season averaged 324.8, 465.2 and 2053.0 kg-C.ha-1 in the 0-50 cm soil for Barley, UVS and Sorghum, respectively. Finally, in topsoil, we showed that higher SRL of barley compared to UVS explain higher rhizodeposition per unit of root mass and different fate. Indeed, higher SRL showed positive association with 13C recovered in Mineral-Associated Organic Matter and microbial biomass (especially from gram positive bacteria).

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GT 03 - 456 - O

ENHANCING BELOWGROUND CARBON INPUTS TO SOIL THROUGH VARIETY SELECTION: A CASE STUDY IN WINTER WHEAT USING A $^{13}CO_2$ MULTIPLE-PULSE LABELLING APPROACH

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Agricultural management measures that promote carbon sequestration in soils are essential for both climate change mitigation and adaptation. Crop roots are the primary source of soil organic carbon (SOC) as belowground carbon (C) inputs —namely root biomass C and rhizodeposition C— persist in soil longer than C derived from above ground crop residues and organic soil amendments and they explore deeper soil layers. Therefore, selecting varieties of main crops with increased belowground C (BGC) inputs has been proposed as a viable option to enhance SOC stocks without compromising yield.

Despite this potential, there is limited understanding of how root biomass C and rhizodeposition C vary among modern commercial crop varieties. Moreover, data are lacking on how these belowground C inputs are influenced by diverse pedoclimatic conditions across Europe, and few studies assess C allocation in deep soil layers.

To address this gap, we implemented an in situ multiple-pulse $^{13}CO_2$ labeling experiment with four commercially relevant winter wheat (WW) varieties, which were selected based on a previous study with 10 varieties on 11 European sites (Heinemann et al., 2025). This replicated field study was carried out across four European countries—Austria, Lithuania, Spain, and Switzerland—to quantify net belowground C inputs after harvest. The WW varieties were isotopically labelled multiple times during their active growth phase. Following harvest, soil and roots were sampled using soil coring to a depth of 1 m.

Roots were recovered from the soil through sequential sieving and washing steps, resulting in three fractions: crown roots, coarse roots (>2 mm), and fine roots (>0.5 mm). Bulk isotope analysis was performed on each root fraction and the sieved soil (<0.5 mm) to quantify net rhizodeposition C.

Preliminary results from the Austrian site show mean total BGC inputs of 2.8 ± 0.14 Mg ha-1. Rhizodeposition C accounted for 47% of total BGC, peaking in the 15–30 cm soil layer, which contained 81% of total BGC. Interestingly, the variety with the lowest root biomass C exhibited the highest rhizodeposition C.

Final results will integrate data from all four countries, providing insight into how varying pedoclimatic conditions influence both root biomass C and rhizodeposition C. Aboveground biomass and grain yield data will also be presented to assess whether selecting specific genotypes can simultaneously support food production and enhance SOC build up.

Note: This study was part of the European Joint Programme on Soil (EJP Soil) project MaxRoot-C.

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GT 03 - 494 - O

THE KEEL OF THE ICEBERG: ELUCIDATING THE IMPACTS OF SCOTTISH WOODLAND EXPANSION ON SOIL ORGANIC CARBON STORAGE IN PODZOLIC MINERAL HORIZONS.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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A growing body of evidence links tree establishment in upland, Scottish, ericaceous ecosystems with soil organic carbon (SOC) losses from the organic horizons of the underlying podzolic soils [1, 2]. This casts doubt on the efficacy of woodland expansion as an anthropogenic climate change mitigation, yet ignores potential impacts in the mineral subsoil, where comparable quantities of SOC are stored [3, 4, 5]. Utilising a long-term, multi-site field experiment, where Betula pubescens Ehrh. (birch) and Pinus sylvestris L. (pine) were slit-planted on Calluna vulgaris (L.) Hull. moorland ca. 20-45 years ago, we inventory SOC stocks, examine soil organic matter (SOM) composition and turnover, and explore linkages to aboveground vegetation structure. Specifically, we test the hypothesis that birch and pine planting induce no net change in mineral horizon SOC stocks, despite shifts in SOM composition and turnover. Here, we present preliminary data on the physical characteristics, SOC contents, thermally fractionated radiocarbon ages, and SOC stocks of organic and mineral horizons from the studied soils. Should no net change, or indeed a net gain, in SOC be detected, then our results will contribute to a more complete picture of the net C balance of a widespread vegetation transition. However, should we detect net SOC losses from the mineral subsoil, they will compound those from the organic horizons, and demand a re-evaluation of woodland expansion's role in Scotland's approach to combatting climate change.

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GT 03 - 530 - O

EFFECT OF SWARD COMPOSITION, URINE DEPOSITION AND SEASON ON SOIL N2O EMISSIONS AND HERBAGE YIELD IN A TEMPERATE PASTURE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Pasture-based agriculture is globally important for food security but faces increasing sustainability challenges. Intensively grazed temperate pastures are increasingly dominated by grass monocultures such as perennial ryegrass (Lolium perenne L.; PRG) and high fertiliser N use with resultant soil N2O emissions that drive climate change and ozone depletion. More diverse grass-clover (PRGWC) and grass-clover-herb multispecies swards (MSS) have significant benefits due to their ability to match or even outyield PRG with much lower fertiliser N. With MSS there may be additional N2O mitigation through enhanced sward N uptake and regulation of soil N cycling by, for example, aucubin release by ribwort plantain (Plantago lanceolata) that can inhibit soil nitrification. However, there is still much uncertainty about the overall effect of such swards on N2O emission in highly-stocked rotationally-grazed pastures with fertiliser N. Urine patches act as N hot spots with N loadings often exceeding plant requirements and tend to drive pasture soil N2O emissions. We hypothesized that MSS would reduce soil N2O emissions from both urine patch and non-urine areas relative to PRG and PRGWC. We tested this hypothesis in a replicated (4 reps) field plot (1.5 x 7 m) experiment in Eastern Ireland on a poorly drained silty clay loam Gleyic Luvisol with synthetic cattle urine applied at three seasons (Spring, Summer, Autumn) to established pasture swards of PRG at 178 kg fertiliser N ha^{-1} yr^{-1} and PRGWC (90% PRG + 10% Trifolium repens) and MSS (35% PRG + 8% Phleum pratense L. + 5% T. repens + 14% T. pratense L. + 27% Plantago lanceolata + 8% Cichorium intybus L.) at 90 kg fertiliser N ha^{-1} yr^{-1}. Emissions were measured over 8 months using the closed static chamber technique and GC and plots were harvested on a 28-day rotation to determine dry matter (DM) yield. MSS significantly outyielded (18,134 kg DM ha^{-1}) PRGWC (17,878 kg DM ha^{-1}) and PRG (15,645 kg DM ha^{-1}) but there were no significant (P>0.05) differences in overall N2O emissions between sward types. However, N2O emissions from urine patches were notably lower for MSS (4,006 g N2O-N ha^{-1}) compared to PRG (4,805 g N_2O-N ha^{-1}) and PRGWC (4,535 g N2O-N ha^{-1}) and the calculated EF for urine deposition on MSS (1.24%) was substantially lower than PRG (2.01%) and PRGWC (1.58%), indicating significant potential to mitigate N2O emissions from N deposited at grazing in urine. The MSS and PRGWC EFs are substantially lower than the IPCC default EF of 2% for urine deposition at pasture. Urine patch emissions were far higher than non-urine (4449 vs. 428 g N2O-N ha^{-1}) and were highest in spring and autumn, coinciding with wetter soil conditions conducive to denitrification, suggesting avoiding grazing under such conditions as a possible mitigation strategy.



GT 03 - 536 - O

REDUCED ATMOSPHERIC PRESSURE AFFECTS SOIL MICROORGANISMS IN ALPINE PLANT RHIZOSPHERES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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In mountain ecosystems, climate change forces plant species to migrate to higher elevations to match their thermal preferences. This upward migration exposes them to reduced atmospheric pressure, affecting some key physical parameters such as vapor pressure deficit, CO2 partial pressure, and gas diffusion. While an exposition to new climatic conditions and changed atmospheric properties are likely to influence plant physiology and growth, the isolated effects of reduced atmospheric pressure remain poorly understood. Completely unexplored are the effects of reduced atmospheric pressure on microbial community composition, microbial activities, and plant-microbe interactions in rhizosphere soil.

Within the international project 'Upshift', we investigate how reduced atmospheric pressure affects upward-migrating plants and their associated soil microorganisms. To isolate the role of pressure from confounding environmental factors such as temperature and humidity, we used the terraXcube climate simulator. Three test plants (Brachypodium rupestre (grass), Hieracium pilosella (forb), and Trifolium pratense (legume)) were collected from a perennial montane grassland at 1500 m a.s.l. within the Long-Term Socio-Ecological Research site (LTSER) Matsch/Mazia (Italy) and exposed to controlled atmospheric pressures simulating elevations of 260, 1500, 2500, and 4000 m a.s.l. After several weeks and alongside eco-physiological plant trait measurements, rhizosphere soils were collected to assess shifts in microbial community composition and activity in response to atmospheric pressure variation.

Our results proved plant-specific effects of atmospheric pressure on plant traits and microbial parameters. Under reduced pressure conditions, rhizosphere microbial biomass increased in B. rupestre and T. pratense, but decreased in H. pilosella and these results were confirmed by respective changes in microbial enzyme activities, indicating consistent shifts in microbial functioning. Moreover, microbial community composition was significantly altered in a plant-species-specific manner due to pressure changes. All observed microbial responses occurred surprisingly independently of measured parameters describing plant physiology or growth. To rule out confounding effects, such as those mediated by a reduced water availability, we conducted complementary laboratory experiments using microbial pure cultures and we proved that reduced atmospheric pressure, within the range experienced across elevations in mountain ecosystems, can alone, directly and distinctly affect microbes.

Together, these findings provide the first evidence for isolated impacts of reduced atmospheric pressure on soil microbial communities under controlled conditions.

GT 03 - 542 - O

OVERCOMING THE LIMITATIONS AT DETERMINING MICROBIAL P IN SOIL: ALTERNATIVES TO THE CLASSIC FUMIGATION-EXTRACTION PROCEDURE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Determining the phosphorus in microbial biomass (MBP) in soils is necessary to understand the P cycle in soils, particularly in agricultural soils where soil fertility management moves from a mineral fertilization to a more integrated and sustainable approach which should take into account recycled fertilizers, increased crop diversity, and the preservation of soil health. Microbial biomass P may account for a relevant portion of P which can become available to plants after microbial biomass decay. The classical fumigation extraction procedure (F-E) relies on gaseous fumigation with chloroform, which makes the procedure harmful. Moreover, some concerns have been raised about the accuracy of the method. One limitation is that P released from microorganisms after cell lysis is adsorbed or precipitated in soils. To overcome this issue, P spikes are applied after fumigation, but this may underestimate the MBP as the interaction between soil and released P is not considered in the 24-hour fumigation process. Three alternatives to the F-E procedure have been assessed with three soils with different physico-chemical properties driving P dynamics (clay, CaCO3, and Fe in oxides content). In two of these alternatives, P-sinks were used during liquid fumigation: anion exchange resin and filter paper impregnated with Fe oxides, which has never been evaluated to this end. The third alternative involved a fumigation with a high-pressure CO2 lysis, without the need for chloroform, reducing the risk associated with the procedure. Results of each procedure, including F-E, varied depending on soil, highlighting the limitations of the classical procedure and its adsorption and precipitation processes. P sinks resulted in higher values of MCP, proving that F-E underestimates the determination of it. Among all the procedures, the use of paper strips impregnated with Fe oxides proved to be the most effective, with an average increase of 52 % of MCP compared to F-E, being at the same time the treatment with the lower variation and higher reproducibility. This new low-cost and reliable method can contribute significantly to the understanding of the microbial P in agroecosystems and the transition to more diversified and sustainable agroecosystems.

KEYWORDS:

Fumigation, Phosphorus, microbial biomass

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GT 03 - 550 - O

HOW DOES THE COMBINATION OF ROOT-CONTRASTED PHENOTYPES INFLUENCE THE MICROBIAL COMMUNITY AND NUTRIENT FLOW UNDER DIFFERENT WATER REGIMES?

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Root architecture adaptation can increase the resilience of agroecosystems to the impacts of climate change, particularly with regards to increasing drought events. To have the perfect root system adapted to all environmental conditions is usually not possible. While a deep root system is better suited to withstand prolonged periods of drought, the development of this root system requires more resources (carbon wise) compared to a shallow root system. A combination of root-contrasted phenotypes (shallow and deep root systems), in contrast, could combine the advantages of both root systems. We were particularly interested in whether co-cropping of root-contrasting phenotypes of spring wheat (Triticum aestivum L.) has a beneficial impact on the C and nutrient fluxes in the soil-micro-biome-plant system under water-deficit conditions compared to single phenotypes in monoculture. We hypothesized that a combination of root-contrasted phenotypes will increase the microbial abundance and enzymatic activity throughout the soil profile compared to the monocultures, especially under water-deficit conditions, due to a more efficient water use and the more homogeneous distributed input of root exudates in top- and subsoil. To test this hypothesis, a column experiment in a climate chamber under controlled conditions was performed. The two phenotypes were grown in mono- and mixed cultures under well-watered (pF 2.5-3.0) and water-deficit conditions (pF 3.5-4.0). During plant growth, 13C pulse labeling of the atmosphere and a 15N fertilization within topsoil and subsoil was performed to gain more detailed insights on microbial nutrient uptake and to identify microbial primary consumers. In contrast to our hypothesis, the combination of root-contrasted phenotypes reduced the transport of assimilated carbon into soil under water-deficit conditions, resulting in lower soil microbial abundance and β-glucosidase activity compared to monocultures. In addition, this result shows that co-cropping of root-contrasted phenotypes might result in reduced C input across the soil profile. The genotypes differed in their major nitrogen uptake zones with the deep-rooting genotype in the mixture targeting deeper soil layers under water-deficit conditions and the shallow-rooting genotype relying more on topsoil nitrogen. This study, therefore, also highlights the potential of combining contrasting root phenotypes in wheat to enhance resource use efficiency in water-limited environments.

GT 03 - 568 - O

MODELING THE EFFECT OF LIMING ON THE FUNCTIONING OF A WINEGROWING VERY ACIDIC SOIL

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Acidic soils affect more than 30% of the world's arable land, pH exerts strong controls on crop production. Soil pH is a fundamental parameter, pH affects nutrient cycling and fertility, microbial community activity, organic matter decomposition, metal availability and inorganic carbon equilibria.

Douro Valley region soils (Portugal) are generally acidic. This region is predominantly characterized by schist-derived soils with low limestone content, which contributes to their high acidity. This feature, along with other edaphoclimatic factors – such as shallow soil depth and sandy loam texture – plays a key role in shaping the distinctive characteristics of the wines produced in this area. The limited depth and texture of these soils also influence their capacity to retain nutrients and water. Although grapevines can tolerate soils with a pH ranging from 4.5 to 8.5, the optimal pH for their development lies between 6.0 and 6.7. For this reason, liming is commonly employed to raise soil pH.

Aiming to study how soil liming and the increase in temperature, associated with climate change, influence CO2 emissions and N mineralization, medium-term incubation was performed with a very acidic soil (pHwater 4.64) from Douro Valley region, a sandy-loam soil with 14.8 g OM kg-1. The laboratory incubation was designed in a complete factorial experiment with five temperatures (5, 15, 25, 35 and 40ºC), five pH levels (4.64, 6.07, 7.14, 7.76, 7.90) obtained by soil liming with CaCO3, and soil moisture equivalent to 40% water-filled porosity (WFP). Samples were incubated during a 28-days period in 3 replications. Previously, a 12-days soil pre-incubation was performed at 25ºC and 20% of WFP. At the end of the incubation, the potential nitrification and the potential activity of the enzymes: β-glucosidase, N-acetyl-β-glucosaminidase, urease and phenol oxidase were evaluated.

Using multiple regressions, it was possible to model soil respiration (R2=0.990) and N mineralization rate (R2=0.951), plotting response surfaces as a function of temperature and pH. Temperature sensitive (Q10) of soil respiration were calculated for the five pH conditions, showing a decrease in Q10 with increasing pH. On the other hand, while the absolute values of N mineralization increase with increasing pH and with increasing temperature, the calculated Q10 for N mineralization show no differences among pH values. Although significant differences in the activity of some individual enzymes were observed with varying pH, the geometric mean of enzymatic activities (GMea), as an overall bioindicator of soil health, revealed no differences among temperature and pH conditions.

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GT 03 - 581 - O

MICROBIAL BIOMASS OF CO2 FIXING MICROORGANISMS IS STABILIZED IN LIGHT AS WELL AS MINERAL ASSOCIATED SOIL ORGANIC MATTER FRACTIONS OF FOREST SOILS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil microbial necromass is suggested to play an essential role in the formation of soil organic matter (SOM). It has been hypothesised that the main mechanism of microbial biomass stabilization is via the in-vivo pathway, where microbial biomass is stabilised directly on soil mineral surfaces. However, despite the recognised contribution of microbial necromass to SOC sequestration, it's uptake into the soil has not yet been studied with natural microbial biomass originating directly from the respective site. To fill this knowledge gap, we incubated four A horizon soil samples from managed beech forests from the Schwäbische Alb (clay-rich) and the Schorfheide-Chorin (sandy) regions in Germany with a mixture of 2% (v/v) 13C labelled CO2 and 98% CO2-free synthetic air for 2 weeks. During the incubation we applied standard conditions (temperature: 20°C, water holding capacity: 60%). The incubation led to a significant uptake of 13C-labelled CO2 by CO2-fixing microorganisms. After the initial incubation, the headspace of the incubation jars was filled with 100% CO2-free synthetic air and the soil samples were further incubated for 0, 2, 4 and 9 weeks. Finally, the SOM was separated in a light and mineral-associated fraction by density fractionation using sodium polytungstate with a density of 1.6 g cm ³. 13C analysis was used to determine where the 13C-labelled microbial biomass of the CO2 fixing microorganisms has remained after incubation. First results showed that after 0, 2 and 4 weeks of incubation between 6 and 95 % of the labelled microbial biomass was found in the light fraction and between 5 and 94 % in the mineral associated soil organic matter fraction. We show that significant amounts of microbial biomass from CO2 fixing microorganisms could be stabilized in both, the light and the mineral associated soil organic matter fraction. Our results further suggest, that the stabilization pathways for microbial biomass in soils depended on their properties. While in sandy soils much more microbial biomass can be stored in light fractions, the opposite is true for clay rich soils.

GT 03 - 607 - O

INTERACTIVE EFFECTS OF CARBON, PHOSPHORUS, AND MOISTURE ON SOIL GREENHOUSE GAS EMISSIONS REVEALED THROUGH AN INCUBATION STUDY

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Greenhouse gas (GHG) emissions from soils are a major contributor to the climate impact of agriculture. While emissions of nitrous oxide (N_2O) and carbon dioxide (CO_2) are well-documented, the role of nutrient interactions, particularly phosphorus (P) availability and labile carbon (C), in influencing these emissions remains insufficiently understood.

This research aimed to investigate how variations in i) carbon mineralisation from different Bio-Based Fertilisers (BBFs), ii) soil P levels, and iii) water-filled pore space (WFPS) interact to affect soil GHG emission.

A soil incubation experiment was conducted using Belgian soil characterised with low available phosphorus. Two types of bio-based fertilisers (BBFs) derived from pig slurry were used: a biodried solid fraction and a nutrient-rich concentrate, differing in their carbon mineralisation rates. These BBFs were applied at a rate of 9,000 kg TOC· ha¹, with two phosphorus treatments (0 kg TP· ha¹ and 48 kg extra P added as triple superphosphate - TSP). A negative control (no C or P added) and a positive control (raw pig slurry) were also included. To level up N levels across treatments, mineral fertiliser CAN was applied, as the treatments had varying nitrogen content. The soil water content was adjusted to three levels of water-filled pore space (WFPS) to assess the effect of moisture on emission dynamics. Gaseous emissions of CO_2, N_2O, CH_4, and NH_3 were monitored over 28 days. At the end of the incubation, hot-water extraction for carbon and nitrogen, as well as mineral nitrogen (nitrate and ammonium) and soil-available phosphorus, were analysed.

The results revealed differences in GHG emissions across treatments. Phosphorus addition consistently reduced N_2O emissions, suggesting that phosphorus (P) limitation promotes N_2O release, likely by hindering microbial nitrogen mineralisation. Treatments enriched with labile carbon—such as the nutrient-rich concentrate and pig slurry—showed higher cumulative N_2O emissions compared to the biodried solid fraction, highlighting the role of labile carbon in driving N_2O fluxes. Methane emissions increased in all treatments, regardless of P addition. Conversely, cumulative CO_2 emissions were higher in treatments receiving phosphorus, particularly in those with higher carbon mineralisation rates, such as nutrient-rich concentrate and pig slurry—indicating that phosphorus may stimulate microbial respiration and thus CO_2 release.

This study is among the first to highlight the pivotal role of phosphorus and labile carbon in regulating greenhouse gas (GHG) emissions in soil ecosystems. The findings offer valuable insights into how the strategic management of nitrogen, carbon, and phosphorus inputs can enhance food security while mitigating agricultural greenhouse gas (GHG) emissions.

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GT 03 - 609 - O

POTENTIAL BENEFITS OF CONSERVATION TILLAGE ON THE STABILITY OF SOIL FERTILITY, BIODIVERSITY AND CROP PRODUCTIVITY AGAINST RAINFALL REDUCTION IN MEDITERRANEAN AGROECOSYTEMS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The Mediterranean region is highly vulnerable to climate change, with projections announcing more frequent and severe drought events. In this context, identifying strategies to mitigate the adverse effects of rainfall reduction on agricultural systems is critical. A rainfall exclusion experiment was conducted over two years in a rainfed legume–wheat rotation in the framework of a long-term trial, which compares traditional tillage (TT) with two conservation agriculture practices: reduced tillage (RT) and no-tillage (NT). The aim was to assess the interactive effects of tillage system and drought on soil functioning and crop production, and to determine whether conservation tillage enhances the resistance of soil to drought.

No-tillage significantly enhanced soil water retention—by an average of 35 % compared to TT—and mitigated the impact of drought in the topsoil. Positive effects of NT on soil fertility (N and P contents), microbial activity (dehydrogenase activity) and the structure of the soil nematode community were also recorded. Soil bacterial communities showed a high tolerance to rainfall reduction across the three tillage systems, while fungal litter saprotrophs were reduced by drought.

Legume and wheat crops responded differently to rainfall reduction. For faba bean, aboveground biomass was reduced by 30 % in NT, 50 % in RT and 20 % in TT, but grain yield was unaffected1. For wheat, aboveground biomass was not affected by rainfall reduction, but grain yield significantly decreased, especially in the TT system, where drought reduced grain yield by 31 % 2. Several plant eco-physiological indicators were positively associated to some variables of arbuscular mycorrhizal colonization in the roots of the legume plants, which were promoted in the NT system1. Put together, the results suggest that conservation tillage—particularly NT—could be a suitable alternative for improving the stability of agroecosystems under increasing drought pressure due to its effects on soil moisture, fertility and biological activity.

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GT 03 - 644 - O

MODULATING NITROUS OXIDE EMISSIONS THROUGH GRASSLAND SWARD COMPOSITION: A COMPARATIVE STUDY OF PERENNIAL RYEGRASS AND MULTISPECIES SWARDS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Ireland's land cover is dominated by grasslands, accounting for 60% of the total land cover area. In grazed grasslands, the frequent application of synthetic nitrogen (N) fertilizers to promote forage growth, combined with urinary N deposition from grazing livestock, constitutes the primary source of nitrous oxide (N_2O) emissions. These N pools from agriculture account for 92.5% of total N_2O emissions in Ireland. Under the 2021 Climate Action Plan, Ireland' is required to reduce GHG emissions from the agricultural sector by 25% by 2030. The aim of this study was to investigate the effect of sward type, perennial ryegrass clover (PRG) and multi-species (MSS) on reducing N_2O emissions from fertilizer and urine treatments. The study was conducted for three seasons from March to December 2024 at the Teagasc Environmental Research Centre, Wexford, Ireland, on two grassland systems MSS and PRG. Static chamber measurements of N2O were made from three treatments – urine (U), proected urea (PU) and a control © , with four replicates each, over 3 seasons (spring, summer, autumn). Sward type had a significant effect on N2O emissions from U and PU treatments. Total N_2O-N emissions following U application were substantially higher in the PRG system compared to the MSS across corresponding seasons. Specifically, emissions under Urine in MSS (882 ± 64.4 g N_2O-N ha^{-1}) were about 50% lower than in PRG (1807 ± 75.5 g N_2O-N ha^{-1}). Across the seasons, the highest total N_2O emissions occurred in the PRG system during spring (2373 ± 89.2 g N_2O-N ha^{-1}), while the lowest were recorded in MSS during summer (818 ± 42.7 g N_2O-N ha^{-1}). In addition the emissions intensity (dry matter yield scaled emissions,DYE) under Urine was significantly higher in PRG than in MSS. DYE in MSS (194 ± 9.3 g N_2O-N Mg^{-1} DM) was approximately two times lower than in PRG (417 ± 20.0 g N_2O-N Mg^{-1} DM). The highest DYE under Urine was recorded in PRG during spring (553 ± 45.8 g N_2O-N Mg^{-1} DM), while the lowest was observed in MSS during autumn (170 ± 14.1 g N_2O-N Mg^{-1} DM). Similarly, under ProUrea application, DYE was considerably lower in MSS (61.3 ± 3.4 g N_2O-N Mg^{-1} DM) compared to PRG (133.3 ± 10.8 g N_2O-N Mg^{-1} DM). The findings of this study show that sward composition significantly influences N_2O emissions in grasslands. Multispecies swards consistently reduced emissions compared to perennial ryegrass, without compromising productivity. These results highlight the potential of nature-based solutions such as incorporating diverse swards into pastoral systems to play a significant role in reducing agricultural emissions and supporting Ireland's climate commitments. Further research is needed to assess their long-term impacts, broader implementation, and practical adoption.

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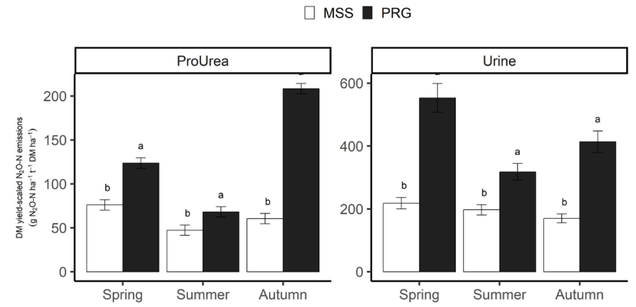


Fig.1. Effect of grassland sward type on dry matter yield-scaled nitrous oxide (N2O-N) emissions under ProUrea and Urine. Bars represent mean values ± SE (n=4) for two sward types: MSS (Multi-Species Sward) and PRG (Perennial Ryegrass Clover) across three seasons (Spring, Summer, Autumn). Different letters indicate statistically significant differences ($p < 0.05$) between sward types within each season.



GT 03 - 658 - O

SOIL ORGANIC MATTER STORAGE AND COMPOSITION AS MEDIATED BY LAND USE INTENSITY AND PEDOGENIC AND CLIMATIC FACTORS IN TEMPERATE GRASSLANDS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Grasslands provide important ecosystem services, such as carbon storage through the accumulation of soil organic matter (SOM) [1]. As a heterogeneous soil component modulated by pedogenic and climate factors [2,3], SOM is best understood by distinguishing between its two contrasting pools, particulate organic matter (POM) and mineral-associated organic matter (MAOM) [4]. In managed grasslands characterized by high land use intensity (LUI), SOM storage may be adversely affected by the decoupling of carbon (C) and nitrogen (N) inputs. However, the differentiation of SOM pools and the complex interactions of pedogenic and climatic factors influencing SOM storage and composition in real-world managed grasslands remain poorly understood. We hypothesize that larger LUI may induce a lower POM-C and MAOM-C contribution in topsoils due to increased N inputs that stimulate microbial decomposition favouring the retention of decomposed forms of organic matter and necromass ; in contrast, subsoils would exhibit a weaker, yet detectable, response to LUI likely derived from topsoils bioturbation. To investigate this, we analyzed soil samples (0-10 cm, 10-20 cm, and 20-30 cm depth) from 75 grassland plots across a LUI gradient in three different regions of Germany, as part of the Biodiversity Exploratories. The bulk organic C and total N content were not related with LUI, even when differentiated into POM and MAOM fractions. However, higher LUI was associated with lower C:N ratios in both POM and MAOM as primarily driven by increased N input via fertilization. Random forest models showed that the role of LUI was masked by mineral properties, particularly clay and iron oxide content, primarily influencing the C:N ratios of SOM fractions. The strong relationship between pedogenic oxides and POM fractions indicate an important role of an increased stabilization of occluded OM in aggregates in soils with higher fine mineral particles. Soil types and mineral properties, thus, condition SOM storage in response to direct LUI effects. As for climatic factors, precipitation was especially relevant for MAOM C:N, likely due to enhanced interaction of dissolved SOM with mineral surfaces after microbial decomposition. Further findings on subsoils along the LUI gradient and differences across the depth gradient will be presented at the conference. Our results provide insights into the interplay of grassland management intensity with a wide range of pedo-climatic factors for SOM C and N storage at regional scale, which could become especially relevant in the context of anthropogenic pressures and changing climatic conditions.

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GT 03 - 721 - O

GREENHOUSE GAS MITIGATION IN RICE CULTIVATION THROUGH HOLM-OAK BIOCHAR APPLICATION AND ALTERNATE WETTING AND DRYING IRRIGATION

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Rice cultivation, particularly under traditional continuous flooding systems, represents one of the most significant anthropogenic sources of greenhouse gas (GHG) emissions, especially methane (CH_4) and nitrous oxide (N_2O). Given the increasing demand for sustainable agricultural practices, it is essential to develop management strategies that reduce these emissions without compromising crop productivity. Promising alternatives include the use of organic soil amendments such as biochar and the adoption of alternate wetting and drying (AWD) irrigation regimes.

This study aimed to assess the medium-term effects of holm oak (Quercus ilex) biochar and different water management practices on GHG emissions in rice cultivation. A three-year field experiment (2020–2022) was conducted, comparing four treatments: traditional flooding (F), traditional flooding with biochar (F-B), AWD irrigation (AWD), and AWD with biochar (AWD-B). Greenhouse gas emissions (CH_4 and N_2O) and soil total organic carbon (TOC) were monitored throughout the crop cycle. The results from 2022, representative of medium-term impacts, demonstrated a clear trend of GHG mitigation through the combined application of biochar and AWD.

Cumulative CH_4 emissions were highest in the F treatment (209 kg ha-1), but were significantly reduced to 50.1 kg ha-1 under F-B. The AWD treatment further decreased CH_4 emissions to 20.9 kg ha-1, while AWD-B achieved a drastic reduction to just 2.29 kg ha-1-a 98.9 % decrease compared to the F treatment.

For N_2O emissions, the F treatment showed the highest value (8.17 kg ha-1), which was reduced to 2.19 kg ha-1 in F-B. AWD and AWD-B recorded N_2O emissions of 6.34 and 3.79 kg ha-1, respectively. Although the change in irrigation regime had a less pronounced effect on N_2O compared to CH_4, the inclusion of biochar significantly mitigated emissions of both gases.

Global warming potential (GWP), calculated as CO_2-equivalents, further reflected these differences. The GWP of the F treatment was 1.5 times higher than that of AWD, highlighting the environmental benefit of water-saving irrigation. AWD-B yielded the lowest GWP values, confirming its effectiveness in minimizing the climate impact of rice farming.

In conclusion, the integration of AWD irrigation and holm oak biochar represents a highly effective strategy for reducing GHG emissions, particularly methane in paddy rice systems. Its adoption could be a key tool in the transition towards more sustainable and climate-resilient agriculture.

ACKNOWLEDGEMENTS

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GT 03 - 826 - O

EFFECTS OF ALTERNATE WETTING AND DRYING (AWD) ON DRIVING FACTORS CONTROLLING CH_4 EMISSIONS FROM RICE PADDY SOILS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Alternate Wetting and Drying (AWD) is a water-saving irrigation technique increasingly adopted in rice systems as a climate-smart alternative, offering potential to reduce methane (CH_4) emissions. However, mitigation outcomes remain variable, suggesting that the effectiveness of AWD depends on how soil characteristics and residue management influence microbial activity and redox conditions. We hypothesize that the contrasting microbial and redox dynamics occurring during AWD cycles can lead to a hysteresis effect on net CH_4 emissions. This effect may depend on soil texture and residue incorporation depth, which influence redox stratification and substrate availability in the soil profile.

A mesocosm experiment was conducted using two soils of contrasting textures (coarse and fine) and two crop residue incorporation depths (shallow: 0–10 cm; deep: 20–30 cm), in a full factorial design. Following an initial continuous flooding period, two AWD cycles were implemented, progressively lowering and raising the water table in 10 cm increments. During these cycles, CH_4 fluxes and $\delta^{13}C$-CH_4), soil redox potential at multiple depths, and porewater chemistry (including Fe^{2+}, DOC, dissolved CH4, and $\delta^{13}C$-CH_4) were continuously monitored.

Preliminary results suggest a nonlinear and asymmetric CH_4 response to drainage and reflooding phases, consistent with a hysteresis effect. Redox potential increased during drainage, temporarily suppressing methanogenesis and partially enhancing CH_4 oxidation. However, emission reductions varied across treatments. Deeper straw incorporation (20–30 cm) resulted in higher CH_4 emissions during drainage phases when the water table dropped below –10 cm, compared to shallower incorporation. This suggests that under dry conditions, anoxic microsites at depth, enriched in labile organic carbon, can maintain active methanogenesis, while reduced water-filled pore connectivity may hinder oxygen penetration and CH_4 oxidation.

These findings highlight the importance of vertical interactions between redox conditions and carbon availability in determining CH_4 responses to AWD. While AWD shows potential for mitigation, its effectiveness may be sensitive to residue management and soil physical properties. Ongoing isotopic analyses ($\delta^{13}C$-CH_4) aim to disentangle the relative contributions of microbial and physical processes to observed fluxes. This study contributes to a process-level understanding of CH_4 dynamics under AWD and informs strategies to optimize its implementation for climate mitigation in rice systems.

GT 03 - 842 - O

SPATIAL AND TEMPORAL VARIABILITY IN FOREST SOIL COMPACTION EFFECTS ON METHANE FLUXES AND ASSOCIATED BACTERIAL AND ARCHAEAL COMMUNITIES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Methane (CH_4) oxidation in forest soils constitutes the largest biological sink for this potent greenhouse gas globally. However, previous studies have demonstrated that soil compaction due to logging operations significantly reduces the potential rate of CH_4 uptake. Compaction typically results in hypoxia, anoxia, and waterlogging, thereby impairing the biological functioning of forest soils. These altered conditions may lead not only to a decline in CH_4-consuming microorganisms (methanotrophs) but also to an increase in CH_4-producing microorganisms (methanogens). However, such shifts in microbial community structure and function are often spatially and temporally heterogeneous.

In this study, we investigated whether the reduction in CH_4 uptake observed in forest soils compacted by heavy machinery seven years prior could be attributed to quantitative and qualitative changes in methanotrophic and methanogenic microbial communities. Soil samples were collected across two depths (0–10 cm and 10–20 cm) and in different seasons. The abundance and diversity of functional genes associated with CH_4 oxidation (pmoA) and CH_4 production (mcrA) were assessed using quantitative PCR and molecular fingerprinting techniques. Additionally, the overall diversity of bacterial and archaeal communities was evaluated through next-generation sequencing (NGS) of 16S rRNA genes.

In situ CH_4 flux measurements indicated an imbalance between CH_4 production and consumption, closely associated with variations in soil moisture. Our results demonstrated that the effects of soil compaction on the abundance of both pmoA and mcrA genes were dependent on both season and soil depth, whereas gene polymorphism appeared less affected by these factors. Specifically, pmoA gene abundance was significantly lower in compacted soils compared to controls across all seasons, except in winter at 0–10 cm depth and in summer at 10–20 cm depth. Conversely, mcrA gene abundance was higher in compacted soils than in control soils during winter and autumn at both sampled depths.

Metabarcoding analyses of bacterial and archaeal communities revealed a significant reduction in microbial richness in compacted soils, particularly within depressions (hollows), relative to control plots. Notably, microbial communities from elevated areas (mounds) in the compacted soils were compositionally distinct from both the controls and the hollows.

These findings underscore the importance of accounting for spatial and seasonal variability when evaluating the long-term impacts of physical disturbances such as soil compaction on CH_4 dynamics and associated microbial communities in forest ecosystems.



GT 03 - 854 - O

DEVELOPMENT OF AN AUTOMATED NDIR-BASED SYSTEM FOR CO_2 SOIL FLUX ANALYSIS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Greenhouse gas emissions are steadily increasing, and their accurate detection is critical for understanding environmental impacts of agricultural activities. In this study, we present a fully automated, high throughput non-dispersive infrared (NDIR) sensor-based system specifically designed for the quantification of carbon dioxide (CO_2) emitted from soil environments. The analytical instrument was developed by Lita Analytical to provide reliable, real-time monitoring in field and laboratory conditions and will serve a strong alternative to gas chromatography.

A calibration model was developed and validated through comprehensive repeatability and accuracy tests. Each measurement cycle lasted 170 seconds, and CO_2 concentrations at 1000 ppm were detected with a repeatability of less than 3%. Measurements performed using a custom-designed chamber setup demonstrated a relative standard deviation (RSD) below 3%, confirming the robustness and stability of the system for soil flux analysis.

This compact and cost-effective device represents a promising tool for large-scale greenhouse gas monitoring in agricultural and environmental applications.

KEYWORDS

greenhouse gas detection; CO2 detection; NDIR sensor; environmental sustainability; soil flux analysis, climate change

GT 03 - 151 - F + P

SIMULATING THE POTENTIAL TO INCREASE MAIZE YIELDS AND MITIGATE CLIMATE CHANGE BY ADOPTING INTEGRATED SOIL FERTILITY MANAGEMENT ACROSS DIFFERENT REGIONS IN KENYA.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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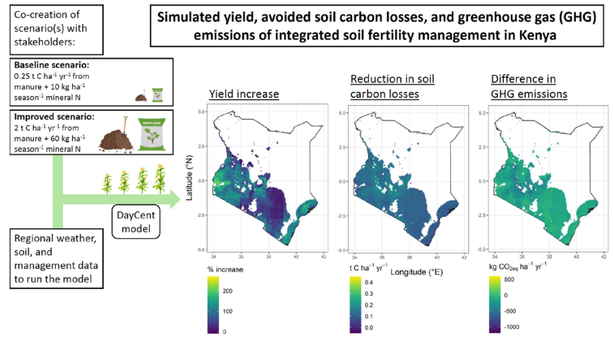
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Strategies to mitigate soil greenhouse gas (GHG) emissions (N2O and net CO2) from agriculture are essential for meeting climate targets. Integrated Soil Fertility Management (ISFM) has been proposed as a means to improve soil fertility and yields, but its net effect on GHG fluxes likely depends on soil and climatic conditions and thus requires careful assessment. This study utilized the DayCent model, calibrated to four Kenyan long-term experiments, to explore the impact of ISFM by simulating 30-year average yields of maize monoculture across Kenya under 17 different ISFM scenarios, which were co-created with Kenyan agricultural stakeholders. We compared yields, changes in SOC stocks and N2O emissions to current baseline conditions (monocropping with minimal nutrient inputs). Monte Carlo simulations based on parameter uncertainties from the calibration, were used to assess prediction uncertainty. The scenario that best represented a 'feasible-input' level consisted of inputs of 2 t C farmyard manure ha-1 yr-1 and 60 kg mineral N ha-1 season-1; other scenarios included different amounts (0, 1, and 2 t C ha-1 yr-1) and types of organic resources in combination with four mineral N fertilizer rates (0, 30, 60, and 90 kg N ha-1 season-1).

The model results indicate a significant potential for yield improvements in the humid regions of western Kenya (from 3.7 to 8.1 t ha-1 yr-1) with the 'feasible-input' compared to the baseline scenario; with GHG emissions per kg of yield generally being lower (the median value decreased from 0.9 to 0.5 kg CO2-eq kg-1 yield). However, in the semi-arid regions of eastern Kenya, maximum yields under any scenario were 1.1 t ha-1 yr-1, reached at inputs of 1 t farmyard manure C ha-1 yr-1 or 60 kg mineral N ha-1 season-1. The uncertainty analysis showed a high confidence in the 'feasible-input' scenario's ability to increase yields and reduce SOC losses compared to the baseline, but a high uncertainty regarding its impact on GHG emissions. Specifically, the 95% credibility intervals for the combined CO2 and N2O emissions ranged from reductions of up to 1000 kg CO2-eq ha-1 yr-1 to increases of up to 200 kg CO2-eq ha-1 yr-1. In conclusion, the model results strongly support the use of ISFM practices to enhance maize yields and mitigate soil fertility losses, with a recommended focus on sites with sufficient rainfall. However, due to the high uncertainty surrounding simulated N2O emissions, we cannot establish with certainty whether ISFM reduces GHG emissions on a per hectare basis or increases them.



Graphical Abstract



GT 03 - 218 - F + P

DOMINANCE OF TEMPERATURE, CHEMICAL RECALCITRANCE AND ORGANO-MINERAL PROTECTION IN PRIMING EFFECT REGULATION

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Consensus is emerging that the turnover of native soil organic carbon (SOC) through the priming effect (PE) can be controlled and influenced by plant, soil, and climate variables. Here, we apply a systematic approach to quantitatively assess the relative importance of plant C input quality, SOC stability, and climate warming in regulating the PE as part of a microcosm incubation experiment using 13C-labelled plant C inputs. Based on multiple analytical and statistical approaches, our study emphasizes the critical role of temperature in regulating the PE, with warming generally leading to negative values. Further, our data indicate the importance of chemical recalcitrance together with organo-mineral protection for PE regulation under future climate warming. Moreover, our findings challenge contemporary concepts holding mineral-associated organic matter fraction and microbial necromass as stable soil organic matter pools.

ACKNOWLEDGEMENTS

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GT 03 - 666 - F + P

INDIRECT NITROUS OXIDE EMISSIONS FROM REPRESENTATIVE STREAMS IN AGRICULTURAL WATERSHED IN SOUTH KOREA

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Nitrous oxide (N_2O) emissions from agriculture are classified into direct (from soils) and indirect (via water systems) sources. Indirect emissions occur when nitrogen from fertilizers or manure applied to croplands—such as paddy fields, uplands, and orchards—leaches or runs off into nearby streams. Approximately, 30% of applied nitrogen is lost through this pathway and contributes to N_2O emissions via aquatic nitrogen cycling. This study assessed indirect N_2O emissions in 2024 across four major agricultural watershed in South Korea- Yeongsan, Geum, Nakdong, and Seomjin by monitoring stream water quality and gas emissions. Seasonal variation was considered through sampling during the pre-farming (Jan–Mar), farming (Apr–Oct), and post-farming (Nov–Dec) periods. Water quality parameters (pH, EC, temperature, TOC, TN, TP, NH_4^+-N, NO_3^--N, DO) and N_2O emissions were analyzed using standard methods and the headspace method. N_2O emissions were significantly higher during the farming season (0.993 μg L^{-1}) than in the pre- (0.513 μg L^{-1}) and post-farming seasons (0.780 μg L^{-1}) ($P = 0.008$), as were TOC and TP ($P < 0.001$). Conversely, NO_3-N concentration were lowest during the farming season (1.14 mg L^{-1}) and peaked in the post-farming season (2.02 mg L^{-1}) ($P < 0.001$), due to plant uptake and leaching. Among the watershed, the Geum watershed exhibited the highest N_2O emissions (1.11 μg L^{-1}), likely due to proximity to a livestock facilities, while the Seomjin watershed showed the lowest emission (0.424 μg L^{-1}) ($P < 0.001$). Theses seasonal patterns reflect fertilizer and manure applications beginning in early farming season. Previous studies reported that 56–64% of riverine particulate organic matter-a key of nitrogen source-is derived from agricultural runoff and rainfall during the farming season. Heavy rainfall enhances nitrogen leaching, promoting N_2O formation. Correlation analysis revealed that N2O emissions were negatively associated with DO and TOC positively with TOC, suggesting microbial activity driven by temperature and nitrogen input plays a key factor. Although this study presents data from single year, extended multi-year studies are in progress to enhance accuracy. These findings underscore the importance of improving national methodologies to more accurately reflect N2O emission through hydrological pathways.

ACKNOWLEDGEMENTS

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GT 03 - 81 - P

EYES HALF SHUT: LONG TERM GLOBAL CHANGE, SOIL EROSION, EUTROPHICATION AND THE SHRINKING OF MOUNTAIN LAKES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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This study attempts to explain the causes and consequences of soil erosion patterns around Lake Lignin, a 2.5 ha lake located at 2400m in the southern alps. It covers the second part of the Holocene, and deals with the role of physical (geology, geomorphology, climate) and anthropogenic (deforestation, grazing) factors, and its consequences in terms of lake ecology. The western part of the lake's catchment is covered with cambisols rich in organic matter with a sandy-loam texture and show little evidence of erosion, while eutrophication is marked. On the eastern side, marlstone outcrops over the entire slope, whatever the gradient. However, a few remnant shreds of loamy cambisols attest to a former pedological cover. The steep slope is deeply gullied which discharge sediments during rainstorms.

Lake sediment cores shows that the Lignin plateau was covered with meadows grazed by flocks from the Bronze Age onwards. Soil erosion increased sharply during the Roman period and then during the Middle Ages. It peaked in the modern period (17th and 18th centuries), coinciding with heavy grazing and the climatic events of the Little Ice Age. During these erosive crises, an increasing proportion of the sediments came from the eastern side of the lake. The most recent sediments indicate that erosion/sedimentation is still very active, leading to the lake filling in within a century. A strong recent accumulation of organic matter in the sediment is accompanied by marked signs of eutrophication, undoubtedly linked to the proximity of herds, to lake filling and to ongoing global warming. Presently, 2/3 of the lake area is filled with sediments. Lake, and soil preservation requires urgent changes in landscape management, and husbandry control.

GT 03 - 115 - P

GLOBAL-SCALE HUMAN PATHOGENIC FUNGI UNDER CLIMATE CHANGE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 16. CONNECTING PEOPLE AND SOILS

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Soils are critical reservoirs of microbial biodiversity, including hundreds of fungal species with recognized pathogenic potential for humans. However, the biogeography and environmental determinants of these pathogens remain poorly understood at the global scale. Here, we provide the first comprehensive atlas of soil-borne human fungal pathogens across 3,200 soils from 108 countries and all major biomes, using long-read PacBio sequencing. We identified 142 pathogenic fungal species, with tropical, arid, and polar ecosystems emerging as hotspots of relative abundance. Generalist pathogens such as Fusarium solani and Mucor circinelloides dominate disturbed soils worldwide, while bioclimatic specialists like Candida tropicalis and Malassezia restricta show strong associations with tropical and arid zones, respectively. Random Forest and RDA analyses identified temperature and aridity as primary drivers of pathogen distribution, with thermotolerant and stress-resistant species favored under warmer and drier conditions.

Predictive models under future climate scenarios (2050, CMIP6) suggest significant shifts in pathogen hotspots toward tropical and coastal areas, overlapping with densely populated and socioeconomically vulnerable regions. This convergence raises urgent concerns for global health equity, as these areas often lack diagnostic infrastructure and access to effective antifungal therapies. The dual-use nature of key fungal traits—thermotolerance, oxidative stress resistance, melanin production—enhances both environmental persistence and pathogenicity, reinforcing the role of climate as an evolutionary filter for virulence.

Our findings underscore the urgent need to integrate fungal disease risk into climate adaptation and soil management strategies. By linking large-scale environmental data with pathogen biogeography, we offer a critical early-warning framework to support surveillance, healthcare preparedness, and policy-making. Monitoring soil-borne fungal pathogens is no longer solely a scientific priority but also it is a socio-economic imperative in an increasingly warming world.



GT 03 - 187 - P

ARE FERTILIZATION-INDUCED DIFFERENCES IN SILAGE MAIZE YIELD RELATED TO THE AMOUNT OF ABOVE- AND BELOWGROUND CROP RESIDUES LEFT AFTER HARVEST?

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Simulation carbon models predicting management-induced changes in soil organic carbon (SOC) stocks in agricultural soils often rely on crop-specific carbon inputs derived from harvest yields and allometric functions. However, there is limited empirical data supporting these functions over a range of yield levels induced by different nutrient regimes. The present study examines the impact of mineral fertilizers and animal manure applied at different levels (deficient, suboptimal, optimal, and over-optimal) on C-input with above- and below-ground residues of silage maize grown in 2023 in the Askov long-term field experiment. To obtain accurate root biomass estimates, we employed two methodological approaches (soil coring and excavation) and compared the field-measured estimates with those derived from allometric functions. Nutrient regime had a significant effect on maize yield but did not significantly affect stubble and root biomass C, challenging the use of yield-dependent allometric functions when modelling C-input to the soil under silage maize. The field measured silage maize C input averaged 1.67 Mg C ha-1 (without rhizodeposition) and ranged from 1.51 to 1.86 Mg C ha-1 with no significant differences between suboptimal to over-optimal nutrient supply. Hence, our findings indicate that relying on fixed C-inputs from maize stubble and roots regardless of nutrient regime and harvest yield provides a more reliable estimate for soil C models than yield-dependent allometrics.

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GT 03 - 247 - P

BOREAL SPHAGNUM FARMING FOR INCREASED BIODIVERSITY AND DECREASED GREENHOUSE GAS EMISSIONS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Interest in establishing Sphagnum paludiculture is on the rise. To date, trials have shown that Sphagnum paludiculture can reduce both greenhouse gas emissions and pressure on fossil peat extraction. However, little is known about the potential of farming Sphagnum in the boreal zone where a substantial proportion of drained peatlands are used for forestry, in addition to industrial peat extraction. In the PEATWAY project we will establish Sphagnum farming field trials at two recently rewetted sites close to Oslo, Norway: (1) a site where peat extraction ceased in the 1950s and (2) a site that was used for Norway spruce rotation forestry until 2024. We will study the carbon balance (net ecosystem exchange and CH4 fluxes) at the Sphagnum farming trials and adjacent plots in which (1) current vegetation is left intact, (2) current vegetation is removed, exposing the peat, and, (3) vegetation is removed and Sphagnum is actively re-established using the moss layer transfer technique. Sphagnum biomass production and plant biodiversity will also be monitored at all fields. Here we will present the project set-up in closer detail and show initial results from the first year of the field experiment.

ACKNOWLEDGEMENTS

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GT 03 - 249 - P

OPTIMIZING THE CLOSURE PERIOD FOR IMPROVED ACCURACY OF CHAMBER-BASED GREENHOUSE GAS FLUX ESTIMATES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Non-steady-state chambers are widely used for measuring the exchange of greenhouse gases (GHGs) between soils or ecosystems and the atmosphere. It is known that non-steady-state chambers induce a non-linear concentration development inside the chamber after closure, even across short chamber closure periods, and that both linear and non-linear flux estimates are impacted by the chamber closure period itself. However, despite the existence of recommendations on how long to keep the chamber closed, it has been little explored to what extent the length of the chamber closure period affects the estimated flux rates, and which closure periods may provide the most accurate linear and non-linear flux estimates.

In the current study, we analyzed how linear regression and Hutchinson and Mosier (1981) modeled flux estimates were affected by the length of the chamber closure period by increasing it in increments of 30 s, with a minimum and maximum chamber closure period of 60 and 300 s, respectively. Across 3,159 individual soil CO2 and CH4 flux measurements, the effect of chamber closure period length varied between 1.4–8.0% for linear regression estimates and between 0.4–17.8% for Hutchinson–Mosier estimates and the largest effect sizes were observed when the measured fluxes were high.

Both linear regression and Hutchinson–Mosier based flux estimates decreased as the chamber closure period increased. This effect has been observed previously when using linear regression models, but the observed effect on Hutchinson-Mosier modeled estimates is a novel finding. We observed a clear convergence between the short-period linear regression estimates and the long-period Hutchinson–Mosier estimates, showing that closure periods as short as possible should be used for linear regression flux estimation, while ensuring long-enough closure periods to observe a stabilization of flux estimates over time when using the Hutchinson-Mosier model. Our analysis was based on soil flux measurements, but because the perturbation of the concentration gradient is related to the non-steady-state chamber technique rather than the measured ecosystem component, our results have implications for all flux measurements conducted with non-steady-state chambers. However, optimal chamber closure times may depend on individual chamber designs and analyzer setups, which suggests testing individual chamber/system designs for optimal measurement periods prior to field application

ACKNOWLEDGEMENTS

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GT 03 - 250 - P

GREENHOUSE GAS MITIGATION POTENTIAL OF NITROGEN FERTILIZER AND BIOCHAR IN BOREAL FOREST SOILS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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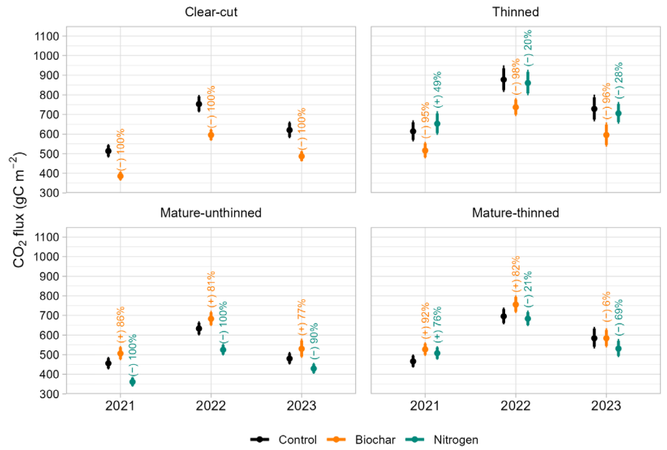
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Boreal forest soils are important storages and sinks of carbon, and they exchange substantial amounts of CO2 and CH4 with the atmosphere. Application of nitrogen fertilizer and biochar in forests, both proposed as means for enhanced carbon stocks and sinks, have the potential to alter the rates of CO2 and CH4 exchange between soil and atmosphere. Previous studies suggest that both soil CO2 efflux and net soil CH4 consumption is decreased after application of nitrogen fertilizer in boreal forests, yet several studies have applied nitrogen at rates much higher than what is common in commercial forestry. Studies on the effects of biochar on boreal forest soil CO2 and CH4 fluxes are rare, but have shown no effect to increased soil CO2 efflux and no effect to decreased net soil CH4 consumption. In other words, considerable uncertainties remain in terms of the effects of nitrogen fertilizer and biochar on boreal forest soil CO2 and CH4 fluxes.

Here, we measured soil CO2 and CH4 fluxes in five different Norway spruce dominated stands at different successional and managemental stages, during three consecutive years, and in response to nitrogen fertilizer and biochar application. Nitrogen fertilizer generally had a minor effect on soil CO2 efflux, and while the uncertainty of the effect on the CH4 flux was larger, there was a consistent pattern of reduced net soil CH4 consumption. Biochar either increased or decreased soil CO2 efflux and net soil CH4 consumption, the direction of the effects being site dependent. Our results show that substantial decreases in soil CO2 efflux and net soil CH4 consumption should not be expected when nitrogen is applied at rates relevant to commercial forestry. The large decreases found in previous studies are likely due to the large-to-extreme amounts of nitrogen applied. For biochar, our results show that it can either increase or decrease net soil greenhouse gas emissions, depending on site-specific conditions.

ACKNOWLEDGEMENTS

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GT 03 - 256 - P

CAN LEGUME COVER CROPS AND PIG SLURRY FERTIGATION REDUCE SOIL GHG AND NH3 EMISSIONS OF MAIZE?

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Agriculture contributes 11% to global greenhouse gas (GHG) emissions [1] and it is the biggest anthropogenic source of nitrous oxide (N2O) emissions, mainly due to the use of nitrogen (N) fertiliser [2]. The traditional method of pre-sowing pig slurry application in maize (Zea mays L.) after a bare fallow comes with high risks of N losses, e.g. in the form of soil N2O and NH3 emissions. The use of legume cover crops (CC) [3] and fertigation [4], which consists in applying the liquid fraction of pig slurry with the irrigation water, may reduce these risks. Fertigating allows supplying N to the crop on a daily basis at a controlled rate, which should improve the N use efficiency and therefore decrease N2O and NH3 emissions.

An on-farm field experiment was established in NE Spain to evaluate the effect of fertigation (no and yes, with 170 kg N ha-1), winter CC (control, faba bean (Vicia faba L.) and rye (Secale cereale L.)) and UAN fertiliser (0 and 150 kg N ha-1). In summer, maize is grown as a cash crop. The UAN is applied at the V6 stage and fertigation from V6 to R1. The study duration is two years (2024-2026) and is arranged in a split-split-plot design with four replications.

The soil was classified as a Typic Calcixerept with a clay-loamy texture (USDA) and a pH of 8.1. Since December 2024, soil GHG and NH3 emissions have been measured weekly in situ using non-steady state dynamic chambers and a Gasmet GT5000 Terra ® analyser. Around fertigation and UAN applications, measurements are intensified. Soil nitrate (NO3-) content (0-10 cm) is determined several times during the campaign. Soil moisture and soil and air temperature are measured with Tomst TM-4 dataloggers ®. Cumulative emissions are calculated using the trapezoidal rule for each gas separately.

Preliminary results of the first year (Fig.1) show a significant effect of the sampling date on CO2- ($p < 0.001$) and CH4- ($p < 0.01$), however not on N2O- or NH3-fluxes. Emissions were not statistically different depending on the CC. Accumulated emissions were not significantly impacted, except N2O emissions which were higher in the control than in rye and higher in 150N than in 0N ($p = 0.029$ and $p = 0.030$, respectively).

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Fig. 1 Gas fluxes over time per cover crop (CC).
Arrows mark the incorporation of CC (red) and sowing (black).

GT 03 - 366 - P

CHANGES IN ENZYMATIC ACTIVITY AND TRANSPIRATION IN FIBRIC HISTOSOLS DEPENDING ON MOISTURE CONDITIONS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 02. SOIL PHYSICAL CHEMISTRY

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Drought is an increasingly frequent abiotic phenomenon occurring across various regions of the world, including Poland. This phenomenon exerts a detrimental impact on forest ecosystems, including forest peatlands, where fluctuations in moisture content can lead to alterations in soil biology, chemistry, and transpiration. In order to better understand these mechanisms, an experimental study was conducted to investigate the effects of drought on changes in chemical parameters, enzymatic activity, and transpiration in Fibric Histosols located in southern Poland. The primary aim of the study was to assess how these parameters vary under different moisture conditions and to obtain insights that could support the mitigation of long-term drought effects. For this purpose, 20 peat soil blocks with intact vegetation were collected from a Fibric Histosols (dimensions: 29 × 30 × 19 cm), comprising 10 soil blocks dominated by Sphagnum spp. and 10 soil blocks containing Sphagnum spp. in combination with Eriophorum vaginatum. The samples were characterized by a high, natural moisture content. After transport to the laboratory, the soil blocks (five replicates per vegetation type) were placed in phytotron chambers, where controlled environmental conditions were maintained for the entire duration of the experiment (four months). The drought treatment involved maintaining a soil moisture level of 30%, while the control (natural moisture) treatment maintained 80% moisture. In both variants, a constant temperature of 20°C was applied. At the end of each month (during the first three months), soil samples were collected from a depth of 15–19 cm for laboratory analyses. These analyses focused on the activity of two soil enzymes Dehydrogenase and β-glucosidase as well as chemical parameters such as pH (H_2O), total carbon (C), nitrogen (N), calcium (Ca), potassium (K), magnesium (Mg), and sodium (Na). In addition, transpiration rates were measured weekly over the four-month period using an Automated Soil CO_2 Exchange Station ACE (ADC BioScientific Ltd). The results obtained from this experiment provide important informationinto the mechanisms by which drought affects peat soils and contribute to a deeper understanding of the dynamics of changes in their chemical and biological properties. Understanding these processes is crucial for the development of effective peatland management strategies, particularly in the context of ongoing climate change.



GT 03 - 370 - P

EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FROM THE FOREST FLOOR UNDER DIFFERENT TREE SPECIES: RELATION TO SOIL PROPERTIES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Tree species composition plays a critical role in shaping carbon (C) and nitrogen (N) dynamics within forest ecosystems. While volatile organic compound (VOC) emissions from above-ground tree compartments have been extensively studied, those from the forest floor remain less understood. This study investigated forest floor VOC emissions and soil properties and processes under three boreal tree species - silver birch (Betula pendula), Norway spruce (Picea abies) and Scots pine (Pinus sylvestris) - within a common garden experiment in Taivalkoski, Northern Finland (65.32°N, 28.16°E). Three metal frames for VOC sampling were placed on the forest floor of single-species plots of each tree species (40 × 40 m). VOCs were collected three times during the growing season using multi-bed adsorbent tubes and later analysed by thermal desorption gas chromatography-mass spectrometry (TD-GC-MS). Environmental variables such as air and soil moisture, temperature and vegetation cover were recorded during each sampling event. Forest floor characteristics were assessed from composite samples of 15-20 soil cores around each frame. Diffusive fluxes of soil N were determined using microdialysis sampling technique in the early and late growing season. Results showed that VOC emissions had high spatial and temporal variation. VOC emissions were highest from the forest floor of pine plot, where the emissions were dominated by monoterpenes, especially α-pinene. Methyl salicylate was the most emitted VOC from birch and spruce plots. Inorganic N fluxes showed both seasonal and species-specific variation: NH_4-N fluxes increased in the late season and were significantly higher under birch compared to spruce. The total inorganic N flux (NH_4-N + NO_3-N) was highest in the birch plot. Forest floor characteristics also differed significantly between species. Birch plot had higher pH, microbial biomass C and N, total KCl-extractable N concentration and N mineralisation rate, and lower C/N ratio, indicating higher N availability and microbial activity. Pine plot had greater forest floor thickness and dissolved organic carbon and KCl-extractable amino acid concentrations, while spruce plot had higher moisture content. Our results highlight the influence of tree species identity on VOC emissions and nutrient cycling, suggesting species-specific interactions between vegetation, soil chemistry and microbial processes that shape forest ecosystem functioning.

GT 03 - 444 - P

SOIL CARBON DYNAMICS AND NUTRIENT AVAILABILITY UNDER DIFFERENT TILLAGE AND FERTILIZATION PRACTICES IN REWETTED SOILS UNDER EXTREME DROUGHT CONDITIONS: THE BIRCH EFFECT

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil carbon dynamics are a key process for agricultural sustainability and climate change mitigation, especially in regions vulnerable to drought. The Birch effect, which describes the abrupt release of CO_2 following the rewetting of dry soils, is particularly relevant in this context. However, the factors that modulate its intensity, such as soil management practices and fertilization strategies, require a more precise understanding.

In this study, we evaluated the combined effects of tillage type (traditional, TT vs. reduced, RT) and fertilization (mineral, CT vs. organic with biosolid compost, BC) on carbon emissions and nutrient dynamics during controlled cycles of soil drying and rewetting. The soil samples, collected from a field experiment evaluating different combinations of tillage and fertilization (Coria del Río, Seville), were sieved (<2 mm), adjusted to 60% field capacity (FC), and subjected to controlled drying (5% FC) and rewetting (60% FC) cycles at 25°C. The experiments were conducted under controlled conditions to simulate realistic scenarios of water stress and recovery.

The results indicate that the reduced tillage combined with compost (RT-BC) treatment exhibited the highest soil respiration at the beginning of the drying period, indicating an enhanced microbial activity. The same treatment also released more CO_2 upon rewetting, indicating intense mineralization of soil organic matter. Regarding nutrient dynamics, soils with organic fertilization consistently showed significantly higher nitrate concentrations throughout the experiment, while ammonium levels decreased across all treatments during the drying cycles, without significant differences between treatments. These patterns suggest that fertilization strategies do not only influence soil carbon reserves but may also affect the availability of critical nutrients for plant growth.

Overall, these findings highlight that, in soils exposed to severe drought conditions, the combination of reduced tillage and organic fertilization can intensify microbial activity, promoting greater organic matter mineralization and nutrient release following rewetting events. Further studies are being conducted to elucidate whether this process can lead to the mobilization of stable soil C sources, which could compromise the use of these management options to enhance resilience to climate change.

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GT 03 - 461 - P

SOIL REDOX TUNING FOR REGULATING NI, AS AND CD UPTAKE BY RICE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Considered an emerging contaminant in rice, nickel (Ni) will be subject to European regulatory limits starting from 2026. Its presence in rice grain raises food safety concerns due to its toxicity and allergenic potential, alongside carcinogenic elements like arsenic (As) and cadmium (Cd). European rice is mainly grown in the Mediterranean area, where geogenically Ni-rich soils increase the risk of grain accumulation, although agronomic strategies capable to limit its mobility are still to be developed. The modulation of soil redox potential (Eh) in paddy fields, achieved through a dry–wet alternating irrigation regime with controlled timing, represents a key strategy for regulating the mobilization of contaminants through redox-sensitive processes. Alternate wetting and drying (AWD), increasingly adopted by rice farmers to reduce water use and methane emissions, has contrasting effects on the accumulation of As and Cd in rice. Water management, when aligned with plant development, can reduce the accumulation of As and Cd by acting differentially on key uptake phases: reproductive phase for As, pre-flowering to maturity for Cd. In contrast, the effect of water regime on Ni behavior in the soil–plant system—particularly in relation to phenological stage and mechanisms of uptake and translocation—remains poorly understood. To explore these dynamics, a mesocosm experiment was conducted by applying eight irrigation treatments, including continuous flooding (CF), AWD, and short drying periods timed to specific growth phases. Drying periods applied in the early growing phases often reduced Ni availability in solution and its uptake during stem elongation and panicle initiation, but had limited impact on final Ni accumulation in plant tissues. In contrast, late-season dry treatments (applied at milky and dough stages) were more effective in reducing Ni content in rice plant, suggesting root–shoot remobilization mechanisms occurring during advanced growth phases. Although drying led to a moderate reduction in Ni concentration in solution, a drop in the Fe/Ni ratio was observed, which may affect the ionic competition at the root level and influence Ni uptake through non-specific transporters shared with Fe. These results provide a basis for optimizing soil redox tuning through appropriate water management. The alternation of soil submersion with short periods of aerobic conditions applied at targeted growing phases could support the simultaneous reduction of Ni, As, and Cd concentrations in rice grains.

GT 03 - 505 - P

RAPID ASSESSMENT OF POST-FIRE SOIL ORGANIC MATTER DYNAMICS USING THERMAL ANALYSIS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Wildfires, which impact millions of hectares globally each year, are among the most significant natural disturbances to terrestrial ecosystems [1]. Their effects on soil organic matter (SOM) and soil organic carbon (SOC)—critical indicators of soil health and ecosystem resilience [2,3]—are profound yet not fully understood. This study investigated the recovery of SOC and its molecular composition over a year following wildfires of varying severity (high, moderate, and low/moderate) in the Caldera de Taburiente National Park, La Palma, Spain. Using evolved gas analysis/mass spectrometry (EGA/MS) and thermogravimetry (TG), we analyzed quantitative and qualitative changes in SOM, focusing on the distribution of active and stable carbon pools across two soil depths (0–2 cm and 2–5 cm). The results revealed that high-severity fires caused substantial SOC losses, particularly in the topsoil layer (0–2 cm), with minimal recovery observed within one year. Moderate- and low/moderate-severity fires preserved a greater proportion of active carbon promoting faster and more consistent recovery patterns [4]. The subsurface layer (2–5 cm) showed greater resilience, exhibiting minimal SOM changes regardless of fire severity, likely due to its thermal insulation capacity. Molecular analyses by EGA/MS indicated that fire severity shaped SOC recovery dynamics and influenced the relative abundance of organic compound families, such as lipids, lignins, polysaccharides, and nitrogen compounds. High-severity fires led to the accumulation of more recalcitrant compounds, while lower severities retained higher proportions of labile fractions, accelerating soil regeneration [4]. These findings underscore the critical role of fire severity and soil depth in determining SOC recovery rates and composition. The study highlights the value of combining EGA/MS and TG as a rapid, reliable approach to assessing fire-induced changes in SOM, offering practical insights for post-fire soil health assessment and ecosystem management.

ACKNOWLEDGEMENTS

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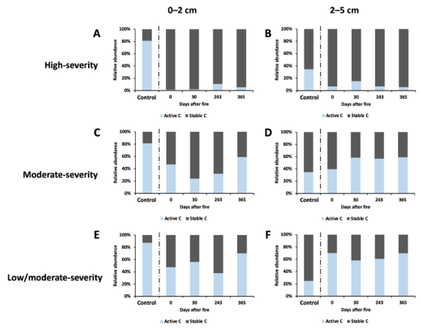
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Relative abundance of active (light blue) and stable (dark) carbon in fireaffected soils across high, moderate, and low/moderate fire severity levels, measured at two depths: 0–2 cm and 2–5 cm.



GT 03 - 604 - P

IMPACTS OF GROUND PREPARATION ON SOIL CARBON IN WOODLAND AFFORESTATION AND REFORESTATION

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 09. SOIL HEALTH

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Soil disturbance caused by ground preparation is well known to result in soil carbon loss by aerating the soil and allowing oxidation, decomposition and leaching. This can reduce expected carbon sequestration by woodlands, with previous models estimating that it may take many years or even up to a full forest rotation of forest growth and litter accumulation to compensate for initial losses depending on soil type and land use change.

Organo-mineral soils represent a significant portion of available tree planting area in the U.K., are carbon rich and vulnerable to degradation of carbon stocks. Long term impacts have been assessed on typical peaty gley soils from a well replicated long term experiment restocked with Sitka spruce in 1980. Above ground biomass and soil carbon stocks were evaluated from 3 different intensity ground preparation methods; ploughing (high intensity), mounding (medium intensity) and ripping (low intensity) against a control of no cultivation and planting next to the stump.

The findings show that ripping caused more soil carbon loss than expected, and both the ripping and ploughing treatments are still affecting soil carbon stock after 40 years. However, the accumulation of litter and fermentation layers as well as better tree growth in cultivated plots have resulted in marginal differences between overall forest carbon balance (above and below ground). These results raise a key question of where carbon should be preferentially sequestered – in the soil or trees when planting second rotation forestry on organo-mineral soils.

Short term impacts of cultivation on mineral soils, by measuring carbon dioxide flux at a natural colonisation site in the year following low intensity ground preparation treatments, have shown increased soil respiration.

This research provides valuable empirical evidence of soil carbon changes from different intensity ground preparation techniques to support field guidance to minimise forestry ground preparation, better quantification of resulting carbon balance between above and belowground, and data to improve modelling in GHG inventories.

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GT 03 - 606 - P

THE DAYCENT MODEL ENABLES THE ASSESSMENT OF CROP YIELDS AND SOIL CARBON STOCKS ACROSS A VARIETY OF CROPPING SYSTEMS IN LONG-TERM EXPERIMENTS ACROSS EUROPE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Agricultural systems are a major source of greenhouse gas emissions, contributing significantly to global climate change. As the demand for food increases, there is a need to identify sustainable soil management practices that minimize environmental impacts while maintaining or enhancing crop productivity. The DayCent model is a useful tool for simulating ecosystem responses (yield, soil organic carbon (SOC) and N2O dynamics) to changes in soil management and climate change. In this study, we calibrated and evaluated DayCent model performance against yields and SOC data collected from nine long-term experiments (PROspective, QualiAgro, Auzeville, La Chimenea, V4, V140, FAST, Knockbeg and COMS) in France, Spain, Germany, Switzerland, Ireland and Northern Ireland. These experiments involve various soil management practices in their design and cover different pedoclimatic conditions across Europe. The treatments in these experiments include conventional to reduced tillage, addition of organic and mineral fertilizers, and the use of cover crops. Data from each experiment was split by treatment into two parts, the calibration dataset and the evaluation dataset. The DayCent model performance was evaluated using common statistical indicators, i.e., RMSE, rRMSE, modelling efficiency, index of agreement and r2. The calibration dataset allowed for adjusting relevant crop parameters according to the standard calibration protocol (Del Grosso et al., 2011)[1]. In model evaluation across all sites, rRMSE ranged from 0.29 to 0.84 for yields, and from 0.03 to 0.16 for SOC stock. The r2 values indicate that the DayCent model predicted 84% and 99% of the measured variability in yields and SOC stock, respectively across the sites, which implies that the model was able to capture the overall variability due to management and pedoclimatic conditions. This study demonstrates that the DayCent model can simulate yields and long-term SOC stock trends under diverse soil management practices across different pedo-climatic conditions and can be used for the upscaling of these practices to the regional scale. In the future task, we will evaluate the model performance to simulate soil N2O emissions and N leaching to be able to provide a robust assessment of the management effects across Europe.

KEYWORDS

DayCent model, Soil management, Soil organic carbon, Yield, Climate change, Long-term experiments



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GT 03 - 610 - P

IMPACT OF TILLAGE AND FERTILIZATION ON CARBON CYCLE ENZYMATIC ACTIVITIES IN MEDITERRANEAN AGRICULTURAL SOILS UNDER DROUGHT CONDITIONS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The carbon (C) cycle is fundamental in agriculture, regulating the flow of organic matter and soil fertility. Enzymatic activities play a key role in breaking down plant residues, releasing organic compounds that plants can absorb. These enzymes reflect microbial activity and soil health, and their presence varies depending on agricultural management and time. Optimizing these activities is essential for maintaining productive and sustainable soils.

In this study, the effects of tillage type (traditional vs. reduced), fertilization (mineral vs. organic), drought (control vs. 30 % rainfall reduction) and season on the main enzyme activities involved in the C cycle were evaluated: β-glucosidase (b-GLU), glucosaminidase (GLA), aminopeptidase (AMI), phosphatase (FOS), phenol oxidase (FENOL), and dehydrogenase (DH). The samples used, collected from the "La Hampa" farm (Coria del Río, Seville), were taken at two key points in the growth cycle of durum wheat (Triticum durum): before crop establishment and at its peak development stage.

The results indicate that enzyme activities increase significantly throughout the crop cycle under different agricultural management practices. Notably, both reduced tillage (RT) systems and organic fertilization (OF) regimes promoted sustained increases in the activity of key carbon cycle enzymes (b-GLU, GLA, FOS, and DH). However, this rise in enzyme activity did not correspond to an increase in soil organic carbon (SOC) in the RT or the OF treatments. This suggests that these enzymes may be driving rapid organic matter decomposition, releasing CO_2 rather than promoting stable carbon accumulation, potentially linked to high microbial activity and good oxygen availability. Rainfall exclusion did not affect the activity of any enzyme.

These findings underscore the critical role of soil management in regulating the carbon cycle but also raise questions about the balance between enzyme activity and carbon accumulation in agricultural soils under water stress.

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GT 03 - 628 - P

BAVARIAN LANDSCAPES UNDER CLIMATE CHANGE - INFLUENCE OF MANAGEMENT AND CLIMATE CHANGE ON INTERACTIONS OF TERRESTRIAL AND AQUATIC ECOSYSTEMS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 09. SOIL HEALTH

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Climate change influences the (nutrient) matter balance in the near subsurface, and therefore the interaction patterns between terrestrial and aquatic ecosystems in cultural and natural landscapes will change and put ecological and economic soil functions and ecosystem services at risk. C and P compounds play a prominent role in the search for mitigation and adaptation strategies. Changes in the metabolic balance of soils and soil-borne sediments are closely linked to changes in the microbiome. The complex interaction patterns in the near subsurface (critical zone) of terrestrial ecosystems are directly linked to aquatic ecosystems via substance inputs to water bodies, whose biodiversity is particularly at risk. In cultural landscapes, the form of land use is of utmost importance, especially grassland and its management. In search of suitable mitigation strategies, the project investigates these changes in the sink and source function of the C/N reservoirs along a climatic gradient in the Bavarian Forest near Regensburg from the montane to the colline stage within the same natural unit. In the context of the project, quasi-natural grassland sites without current and without previous soil management form the reference conditions. They are contrasted with long-term intensively used sites. On the basis of these scenarios, the interactions between landscape and climate will be illuminated and, in comparison with the corresponding regulations such as the Water Framework Directive and the Soil Protection Ordinance, management strategies will be developed with the aim of maintaining soil functions under climate change conditions and reducing undesirable inputs from terrestrial to aquatic systems. In addition to cultural landscape genesis, the structure of the near-surface subsurface with material stocks, layer structure, weathering phenomena, pedogenesis and slope water flow is of fundamental importance. Hence, the interdisciplinary project combines the competences of geomorphology, soil science, microbiology, stable isotope biogeochemistry, hydrology and aquatic systems biology.

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T 03 - 641 - P

CARBON STORAGE AND ACCUMULATION IN PYRENEAN PEATLANDS: ASSESSING THEIR POTENTIAL AS CLIMATE MITIGATORS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Peatlands are critical ecosystems for climate change mitigation due to their substantial soil organic carbon (C) stocks, which have accumulated over millennia. Although they cover only 3% of the Earth's land surface, peatlands store a third of the world's soil C, exceeding the C stored in forests and the atmosphere combined. However, these ecosystems are highly sensitive to climate change and human activities, which threaten their ability to function as net C sinks.

The Pyrenean peatlands, located at the intersection of Temperate and Mediterranean bioclimatic zones, are particularly vulnerable. Over the last 50 years, the Pyrenees have experienced a 1.2°C increase in average temperature and a significant reduction in snow cover, both of which are likely to affect plant community composition and accelerate peat decomposition, with uncertain consequences for C dynamics. Despite their ecological importance, Pyrenean peatlands remain understudied, with critical gaps in our knowledge of their extent, C content, and response to climate pressures, particularly in terms of C accumulation.

To fill these gaps, we quantified C stocks and the net C balance (net ecosystem production) in three peatlands located in the Catalan Central Pyrenees. By combining peat depth measurements, kriging interpolation, C content analysis, and 210Pb-age modelling, we estimated C stocks, C inputs, decomposition rates, and C accumulation rates over the past century in these systems. To provide new insights into the influence of vegetation in C accumulation, we accounted for plant community heterogeneity by differentiating between peatland habitats when estimating C fluxes.

Results showed that short-term C accumulation rates ranged from 0.01 to 0.54 kg C m-2 yr-1, with an average of 0.12 kg C m-2 yr-1. The C stored in these peatlands over the past 80 years varied from 4.4 to 15.9 kg C m-2, and it was significantly dependent on plant community composition.

Our results improved our understanding of how vegetation variability influences C accumulation in peatlands, allowing for more precise scaling of C stocks and net C balance. This contributes to a broader understanding of C dynamics in alpine peatlands, highlighting their current and future role in climate change mitigation. These insights provide a scientific basis for the development of conservation and management policies aimed to protect these unique ecosystems, ensuring their continued contribution to both climate change adaptation and mitigation efforts.



GT 03 - 657 - P

SEASONAL DYNAMICS OF NITROGEN MINERALIZATION IN THE RHIZOSPHERE SOILS OF ALDER AND OAK IN A YOUNG TEMPERATE PLANTATION

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The rhizosphere is a dynamic zone of intense microbial activity and nutrient cycling, but its contribution to nitrogen (N) mineralization compared to bulk soil remains poorly understood in early-stage plantations. Here, we examined seasonal shifts in microbial N transformations in the rhizosphere of Alnus glutinosa (alder) and Quercus robur (oak) within a 5-year-old temperate plantation. We hypothesized that spring would promote higher N mineralization rates due to increased microbial activity, stimulating microbial turnover.

We measured gross and net nitrogen mineralization in rhizosphere and bulk soils under different tree species to assess tree-driven variation in N cycling. Rhizosphere soils were collected directly from the root zones of alder and oak in a 5-year-old plantation in Staffordshire, England. Bulk soils were sampled at a 15 cm depth across the plantation. All samples were collected at the midpoint of each season (spring, summer, autumn) to capture seasonal dynamics. Gross nitrogen mineralization was determined using 15N isotope tracer addition to fresh soil, while net mineralization was calculated from inorganic N accumulation during incubation. Microbial activity was assessed using soil respiration, microbial biomass carbon (MBC) and nitrogen (MBN), and extracellular enzyme activities.

The study revealed that both season and soil origin (rhizosphere vs. bulk) significantly influenced microbial activity ($p < 0.05$). Microbial biomass carbon (MBC) and nitrogen (MBN) were generally highest in spring, while soil respiration peaked in summer, particularly in alder rhizosphere soils—likely due to stimulation from nitrogen-fixing root nodules. In contrast, microbial activity declined in autumn, potentially due to lower temperatures that are less favorable for microbial processes.

Enzyme activity also varied by season and tree species. N-acetyl-β-D-glucosaminidase (NAG) activity was elevated in the oak rhizosphere during spring, though with high variability, suggesting a transient increase in microbial nitrogen acquisition. Gross nitrogen mineralization was highest in spring, 271% and 408% greater than in summer and autumn, respectively, particularly in alder rhizosphere soils. However, this increase was not statistically significant ($p > 0.05$) and did not correspond with gross nitrification, which instead peaked in autumn, especially in bulk soils.

Net nitrogen mineralization followed a distinct pattern, reaching its lowest rate in summer and peaking in autumn. In contrast, net nitrification was highest in spring, showing an opposite seasonal trend to gross nitrification. Ammonium (NH_4^+) and nitrate (NO_3^-) consumption, along with microbial immobilization, largely followed gross mineralization patterns, with the highest rates observed in spring across all soil origins.

Overall, alder rhizosphere soils tended to support higher nitrogen transformation rates than those under oak. These findings underscore the importance of rhizosphere processes and tree species identity in shaping nitrogen cycling during early forest development. Recognizing such seasonal and species-specific patterns is essential for understanding nutrient availability and guiding the management of mixed-species plantations.

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GT 03 - 661 - P

LINKING SOIL PORE ARCHITECTURE TO NITROUS OXIDE PATHWAYS UNDER LAND USE SYSTEMS IN THE AMAZON BIOME

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 02. SOIL PHYSICAL CHEMISTRY

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Soil structure is a dynamic property strongly influenced by soil land use, with direct effects on the biogeochemical cycling of greenhouse gases such as nitrous oxide (N2O). An integrated, multiscale approach is therefore essential to unravel the mechanisms by which land use alters soil structure and nitrogen (N) dynamics, directly influencing N2O emissions. Here, we evaluated how long-term land use systems influence soil pore architecture and the pathways of N2O production in a tropical Amazonian soil. The study was conducted in a 12-year field experiment following three systems: (i) crop-succession (soybean-maize), (ii) integrated crop-livestock system (soybean-maize-palisade grass), and a (iii) well-managed pasture (palisade grass). A multiscale approach was applied by combining synchrotron-based X-ray computed microtomography (SRXCT), soil hydraulic modeling, and 15N-labelled fertilizer tracing. Undisturbed soil samples were collected for incubation experiments and to determine soil hydraulic properties (e.g., inter- and intra-aggregate pore space and air-filled porosity). Soil aggregates (6 mm Ø) were scanned using a SRXCT with low energy (22 keV), indirect photon detection (2x objective), and an effective pixel size of 3.35 µm. 3D image analysis, including reconstruction, segmentation, and quantifications, was performed using Annotat3D, AVIZO, and Fiji. Our results demonstrate that, at the micro-scale soil aggregates, the fraction of pores between 10-30 µm Ø and the global average pore distance play a key role in controlling N2O production by promoting anaerobic microsites favorable to denitrification. Low aggregate porosity and an increase in pores within this size range create denitrification hotspots. In addition, greater inter-aggregate porosity (30-80 µm Ø) and the air-filled pore space enhanced gas diffusion, facilitating the transport of N2O produced in aggregate pores to the atmosphere. The integrated crop-livestock system showed the highest N2O emissions due to a combination of increased nitrate availability, a greater fraction of 10-30 µm Ø pores, higher global average pore distances, and more connected pore networks. In contrast, the well-managed pasture showed lower N2O emissions, likely associated with more stable carbon (C) pools, reduced mineralization rates, lower nitrate availability. Overall, N2O production and emissions were strongly influenced by soil pore architecture, which regulates oxygen availability, microbial activity, and the spatial distribution of N substrates. These results highlight the central role of soil pore heterogeneity and air-water dynamics in mediating N2O emissions and reinforce the importance of land use strategies that consider both macro- and micro-scales to support climate-resilient agriculture in tropical systems.

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FAPESP Foundation (2020/15230-5; 2021/10573-4; 2022/16763-2; 2023/11900-4) and Brazilian Synchrotron Light Laboratory (Proposal 20230479).



GT 03 - 704 - P

EVALUATING THE IMPACT OF COVER CROP AND NITROGEN APPLICATION RATE ON SOIL N_2O SMISSIONS, COMBINING AN AUTOMATIC CHAMBER SYSTEM AND THE DAYCENT MODEL.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Agricultural soils are the main source of nitrous oxide (N_2O) emissions due to various farming practices. Management practices such as adjusting nitrogen fertilizer rates or introducing cover crops, particularly legume-based mixtures during fallow periods, can improve agricultural system efficiency by reducing nitrogen losses in the form of N_2O. The objective of this study was to evaluate the impact of two agricultural practices on soil N_2O emissions: the use of cover crops and the adjustment of nitrogen fertilization rates.

An experimental trial was conducted at the Aula Dei Experimental Station (EEAD-CSIC, Zaragoza), comparing a tilled fallow (F) with a cover crop (CC) consisting of an oat-vetch mixture, and three nitrogen fertilization rates: a control (C) with 0 kg N ha^{-1}, a medium rate (M) of 150 and 200 kg N ha^{-1} for CC and F, respectively, and a high rate (H) of 350 and 400 kg N ha^{-1} for CC and F, respectively, during the maize growing season. Soil N_2O emissions were continuously monitored using an automatic chamber system. Additionally, the data collected were used to parameterize the DayCent model.

Cumulative soil N_2O emissions and yield-scaled N_2O emissions showed significant differences depending on the nitrogen fertilizer rates. In contrast, the implementation of cover crops did not have a significant impact. Similarly, neither grain yield nor the nitrogen emission factor (EF) showed significant differences between treatments. Nevertheless, it is worth noting that the EF values obtained did not exceed 0.25%, which is lower than the 1% threshold established by the IPCC. The DayCent model showed satisfactory performance in simulating soil N_2O emissions.

This study highlighted that the introduction of cover crops, combined with optimized nitrogen fertilization, are effective strategies for reducing external nitrogen inputs and N_2O emissions without compromising the viability of agricultural systems.

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GT 03 - 705 - P

MULTIPLE GLOBAL CHANGE PRESSURES: CASCADING CONSEQUENCES FOR SOIL BIOLOGY AND MULTIFUNCTIONALITY IN THREE MEDITERRANEAN ECOSYSTEMS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Recent scientific evidence highlighting the diminishing capacity of ecosystems to provide vital services, on which human survival depends, has spotlighted the urgent need to deepen research into global change impacts. Global change drivers do not act in isolation; rather, they interact, generating unpredictable effects compared to their independent impacts. This recognition has driven a paradigm shift in global change and ecosystem services research, moving from investigating single causes (e.g., drought, pollution) to emphasizing the need to understand how various abiotic and biotic factors jointly determine ecosystem futures. This need for studying complex environmental responses is particularly acute in traditionally understudied Mediterranean Basin ecosystems. These areas not only provide crucial provisioning and regulating services for local and regional socioeconomic development but also warrant focused study due to their significant biodiversity and spatial-temporal heterogeneity. The objective of this study is to advance scientific knowledge regarding ecosystem multifunctionality limitation and the factors modulating its response to multiple global change drivers. Our hypothesis posits that the service-generating capacity of these Mediterranean ecosystems will be more limited with an increased number of co-occurring global change drivers. Specifically, we anticipate that impacts from increased aridity and enhanced nitrogen deposition will be modulated by plant biodiversity, which will, in turn, determine the response of soil biological communities, leading to cascading effects on soil multifunctionality. This hypothesis has been tested along three natural gradients on different Mediterranean ecosystems: shrublands, dehesas and mixed forests. Each of these gradients encompass five plots which combine different levels of aridity, nitrogen deposition and vegetal biodiversity, leading to plots subjected to 0, 1, 2 and 3 drivers of global change. In this study we will present the preliminary results of soil analyses performed on this experimental setup. This study will contribute to elucidating the underlying mechanisms of simultaneous environmental perturbations in Mediterranean ecosystems. Furthermore, these results will fill a knowledge gap in the study of more than two global change drivers, a pressing yet often overlooked topic in terrestrial ecology, particularly in Mediterranean ecosystems.

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GT 03 - 723 - P

SENSITIVITY OF THE METHANOTROPHIC BACTERIA TO NONANOIC ACID - 'GREEN PESTICIDE'

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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The widespread use of synthetic herbicides (e.g. glyphosate) threatens ecosystems by modifying the composition and activity of the soil microbiota. Bioactive compounds of natural origin that are biodegradable are proposed as an additional active substance, or as an alternative to synthetic herbicides (1). One of the increasingly used 'green' pesticide is nonanoic (pelargonic) acid (PA). Due to its vulnerability to biodegradation, PA is considered relatively safe for soil microorganisms (2). However this assessment does not take into account the effects on methanotrophic bacteria, which are common in the soil environment and, through the oxidation of CH4, play an important role in mitigating the progression of the greenhouse effect. The research presented in this study aims to gain a basic understanding of the susceptibility of methanotrophic bacteria to PA. For this purpose, reference strains of type I and II methanotrophs (Methylomonas methanica and Methylcystis bryophila, respectively) as well as methanotrophic soil enrichment cultures isolated from various agricultural soils (Gleysol, Leptosol and Fluvisol) were used. The results obtained indicate that both reference strains are susceptible to biocidal activity of PA, but have different tolerance level. M. methanica showed significant inhibition of growth and methane oxidation already at a PA concentration of 10 ug ml-1. In M. bryophila cultures, a similar effect was observed at several times higher PA concentrations. Studies performed on soil enrichment cultures confirm these observations. The community isolated from Leptosol, dominated by type I methanotrophs (Methylobacter), showed high sensitivity to PA, in contrast to those isolated from Gleysol and Fluvisol, which were dominated by type II methanotrophs (Methylocystis).

The results indicate that bio-based and biodegradable agrochemicals may also affect the methane oxidation potential of soils.

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GT 03 - 727 - P

GLYPHOSATE - A FRIEND OR FOE? SOIL METHANE UPTAKE AND MICROBIAL COMMUNITY REACTION TO THE PESTICIDE

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Being second only to carbon dioxide, methane (CH4) is one of the key greenhouse gases, responsible for approximately 20% of the global warming [1]. Atmospheric CH4 concentration is constantly increasing, with present-day levels of 1935 ppm [2]. Through functioning as a microbial filter, low-affinity methanotrophs reduce by up to 80% the amount of CH4 that is emitted from soil and released into the atmosphere [3]. As a result of agricultural activities, soil microorganisms, including methanotrophs, are exposed to pesticides. One of most commonly used is glyphosate (GF). In 2018, annual consumption of GF exceeded 8.25 x 108 kg, and estimates for 9.20 x 108 kg by 2025 [4]. Due to the rapid biodegradation and sorption of GF in soil, this compound is considered as safe. However, with intensification of agriculture, its application rates and frequency are increasing considerably. It was anticipated, that due to the physico-chemical (chelatation of essential microelements, e.g. Cu, Zn and Fe) and biological properties (inhibition of shikimic acid pathway) GF may negatively affect methanotrophic activity and methanotroph abundance in the soil.

This study examined the effects of a wide range of GF concentrations (from label- to overdose) on soil CH4 uptake (gas chromatography), microbial community composition (16S rRNA gene amplicon sequencing) and cell count (digital PCR) in Gleysol, Leptosol and Fluvisol. Particular attention was paid to the abundance and diversity of the methanotrophs. Changes in CH4 uptake in all soils treated with GF followed the similar pattern: slight increase under GF label dosage, followed by decrease under overdose conditions. However, there was also a slight increase in methanotroph cell count, and shift in methanotroph community towards facultative taxa. The results indicate the buffering role of soil sorption of GF, and possibility of its utilization by facultative methanotrophs as a nutrient source.

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GT 03 - 754 - P

TOWARD FLEXIBLE, STANDARDIZED TRACE GAS FLUX MEASUREMENTS USING A MULTIPLEXER-CENTRIC, ANALYZER-AGNOSTIC SYSTEM

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Trace gas fluxes, including carbon dioxide, methane, and nitrous oxide, are key components of ecosystem greenhouse gas budgets. Accurate measurement of these fluxes at soil and canopy scales has often been constrained by the lack of standardized systems, historically requiring researchers to custom engineer chambers, gas sampling, and data integration components.

Here we introduce an analyzer-flexible flux measurement platform that centralizes system control and data standardization within a multiplexer (Eosense, eosMX). The system supports direct integration of both small chambers (eosAC-T/O) for soil flux measurements and large chambers (eosAC-LT/LO) for canopy-scale studies, alongside a wide range of gas analyzers. By coordinating scheduling, measurement control, and data harmonization at the multiplexer level, the platform allows researchers to match analyzers to project-specific needs while maintaining similar workflows thereby improving measurement standardization and cross comparability.

We present the system architecture, highlight integration and data processing workflows and share initial performance comparisons between select analyzers using known, generated fluxes under controlled conditions. This approach aims to reduce uncertainty and improve experimental comparability while maintaining flexibility to tailor the analyzer and chamber selection to the unique experimental requirements.

GT 03 - 798 - P

BARLEY GENOTYPES SHAPING SOIL CARBON ALLOCATION.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Roots are the key for climate change adaptation and mitigation. With more and deeper roots, agricultural crops can access deeper water and nutrient resources which makes them more resilient to drought events under climate change conditions. Roots are also the main precursor of soil organic carbon (SOC) with a much higher efficiency to build up SOC compared to other biomass that is left in soils. However, there is a lack of data on the distribution and turnover of roots in different crop types and varieties as well information on the options to maximize root C input to the soil to enhance SOC (Paustian et al., 2016).

We quantified the belowground C allocation for four barley varieties with contrasting root traits, in the field: Morex, Morex1L32, Taffa and Anakin. We did this using a 13C stable isotope labelling approach, which allows us to estimate root carbon inputs and sequestration potential of different crop varieties in the field over significantly shorter times scales than traditional long-term experimental approaches. We were able to estimate annual net root inputs and rhizodeposition and their retention. Moreover, we followed the biological fate and turnover rates in the laboratory and field, allowing us to assess root derived carbon storage and persistence in relation to specific the root traits and functions.

Initial results showed that the variety Anakin had the highest total root mass but this was not significantly different from the other varieties as determined by ANOVA analysis. On average across the varieties, 70% of the root biomass was in the top 15 cm of soil. With 30% root biomass in the remaining 85 cm of the soil profile sampled.

Taffa and Anakin varieties were shown to have the most even distribution of roots down the profile whilst the Morex varieties had lower root biomass beyond the upper 15cm layer. Rhizodeposition was highest in the upper soil layers and significantly different between layers ($p=0.001$). Anakin and Morex-32 had the highest rhizodeposition in the upper 15 cm. Using this approach should allow us to predict the fate of root carbon in a robust replicated manner and will allow us to quickly optimize and iterate management options based on either new incoming scientific evidence, farmer's recommendations, or even the adoption of new farming practices.

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GT 03 - 832 - P

NUTRIENT AND MINERAL RELEASE RATES FROM NASCENT SOIL OF REHABILITATED AGGREGATE PITS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 09. SOIL HEALTH

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Following cessation of surface mining of sand and gravel for road and building material, the province of Ontario, Canada, mandates that an aggregate pit be restored to a viable ecosystem. Rehabilitation measures on these severely degraded landscapes typically involve regrading of steep slopes and a simple hydroseed of the resulting gentle hills. Thus, an ecosystem is left to initiate on barren crushed rock and sand, devoid of any measurable organic matter and minimal nutrients. It is unknown whether these treatments can sustain a healthy level of nutrient and mineral cycling, even two decades post-restoration. To address this research gap, anion and cation resins were deployed for a one-month period at the peak of the growing season in surface soils of five grasslands rehabilitated from sand and gravel pits in glaciated southern Ontario, Canada. The sites were restored between four and 19 years prior to sampling. Resin sticks were installed both vertically, from a depth of 1- to 6-cm below ground, and horizontally, at a depth of 3-cm below ground surface to investigate the release of several nutrients (N, P, K) and minerals (Cu, Fe, Mn, S, Zn) to the plant root environment.

In general, results showed moderate variability between sites, relatively low rates of nutrient and mineral availability, and generally no significant differences between vertical and horizontal placement of resin sticks within a site. Only the oldest restored site had appreciable nitrogen (ammonium + nitrate) sorbed to the resin (20 ug/10 cm/mo vs. ~5 ug/10 cm/mo); however, the oldest site also had a significantly lower release of phosphorus (<5 ug/10 cm/mo) than sites restored 10-12 years ago (between 8 and 32 ug/10 cm/mo). These results generally aligned with stocks of N and P based on bioavailable cold acid extraction tests on the soils. Based on this stoichiometry, the oldest site would be considered P-limited, whereas all the other sites are severely N-limited, with N:P ratios < 5:1. Zinc and Copper release rates were proportionally similar between the sites, but with an order of magnitude higher Zn release than Cu. Somewhat surprisingly, while among the lower release rates between sites, the 12-year post-restoration site with very low organic matter (< 2 %) and very high sand content (> 95 %) did not have significantly lower release rates than any one site . The 2024 growing season was abnormally rainy, with June, July, and August each being among the wettest on record, and this added water likely led to increased release of all anions and cations. Overall, these findings demonstrate very low nutrient and mineral turnover to the soil water environment, which may contribute to poor grassland ecosystem health, even after nearly 20-years post-restoration. While likely at significant cost, the addition of even a little organic matter during the rehabilitation process is likely to significantly improve soil nutrient and mineral nutrition.

GT 03 - 843 - P

RECURRENCY OR RECENCY? TEMPORAL FACTORS INFLUENCING MEDITERRANEAN FOREST SOILS AFTER FIRES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Fires may entail a detrimental but relevant disturbance for maintaining many ecosystems worldwide, playing a critical role in preserving biodiversity and ecological functions. In soil, fires may either contribute to the dynamic equilibrium or trigger irreversible degradation depending on the ecosystem's resilience capacity and the fire regime of each stand. As a result of global change, parameters in the fire regime like fire frequency might increase in Mediterranean ecosystems, which is extremely worrying as they are highly vulnerable to degradation due to the low organic matter content of their soils.

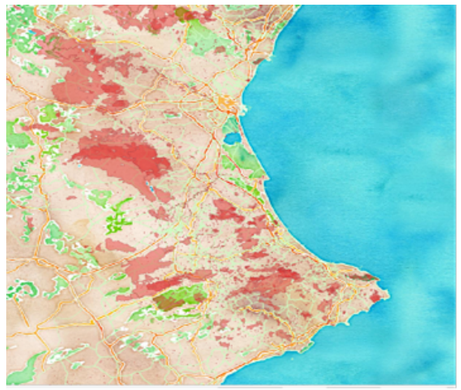
To tackle how soil properties may change due to fire regime, we assessed the effects of increasing recurrent fires on soil chemical, physical, and biochemical properties in Mediterranean ecosystems in southeastern Spain. We analyzed 96 composite soil samples (0–5 cm depth) from 8 sites with varying fire histories (0 to 4 fires in a 50 year period). Mixed linear models were used, with fixed effects including fire presence, number of fires in the past 50 years, time since the last fire, and the time interval between the two latest fires. Random effects accounted for site, vegetation, immediate ground cover, and soil color.

Our results show that fire significantly altered nearly all chemical, physical and biochemical features. Increased fire recurrency was significatively associated with remarkable shrinking in soil water repellency and some reduction in aggregate stability, indicating a destruction of hydrophobic compounds with more frequent fires. Anyway, aggregate stability remained high, suggesting that soil physical resistance may cope with the studied fire regimes.

In contrast, changes in soil chemical properties were linked to the time elapsed since the last fire and the interval between recent fires, suggesting that changes associated with the ecological succession after the last fire dominate over those associated with fire history. Biochemical properties reflected the combined influence of all three explanatory variables; because they are sensitive parameters, the observed alterations capture the complexity of fire histories.

Our findings suggest that both fire frequency and the time since the last fire may be key drivers of soil change in the studied ecosystems, but they exert distinct effects on soil properties. Soil resistance in the soils studied might be high enough to resist the impact of an increased fire recurrency, which could confer an advantage for Mediterranean ecosystems to tolerate fire regimes shifts.

By differentiating the impacts of fire recurrence from post-fire recovery periods, this study advances our understanding of fire-soil interactions and provides new insights for sustainable forest management and soil conservation in fire-prone Mediterranean ecosystems.



Fire history in red in the studied region (Alicante province, Spain) since the 90's



GT 03 - 871 - P

EFFECTS OF HIGH TEMPERATURES ON HEAVY METAL DYNAMICS AND OXIDATIVE STRESS IN MEDICAGO SATIVA GROWN UNDER VARYING SOIL CONTAMINATION LEVELS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Global warming and heavy metal pollution are two major environmental challenges affecting agricultural systems. Rising temperatures, as projected by the IPCC, may exacerbate the mobility and uptake of toxic metals in crops, posing risks to ecosystems and human health. While temperature effects on plant growth are well documented, their combined impact with soil contamination on metal accumulation and plant responses remains poorly studied.

This study aims to evaluate the effects of elevated temperature on heavy metal speciation in soil and the physiological and biochemical responses of alfalfa plants (Medicago sativa). Plants were exposed to three temperature regimes (25°C, 27°C, and 29°C) for 60 days. Agronomic parameters, including shoot and root length, as well as chlorophyll content, were measured. The concentrations of Pb, Zn, Cd, and Cu in soils, roots and shoots were quantified via chemical analysis. Additionally, oxidative stress biomarkers such as malondialdehyde (MDA), glutathione-S-transferase (GST), and catalase (CAT) were assessed.

Our data showed that the highest temperature (29°C) increased the bioavailability of Zn, Pb, and Cd, leading to greater accumulation in alfalfa tissues grown in contaminated soil. Biochemical analyses revealed that the antioxidant defense system was significantly affected under the combined stress of elevated temperature and heavy metal exposure, as evidenced by increased CAT and GST activities.

These findings highlight the need to consider temperature as a key factor influencing heavy metal behavior in soils and their potential impact on crop health and food safety under climate change.

KEYWORDS

Heavy metals, Temperature, Alfalfa, Bioavailability, Oxidative stress.

GT 03 - 892 - P

AN INTEGRATED CHAMBER, GAS SAMPLING AND DATA PROCESSING SYSTEM FOR CANOPY SCALE MEASUREMENTS OF PLANT MEDIATED TRACE GAS FLUXES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

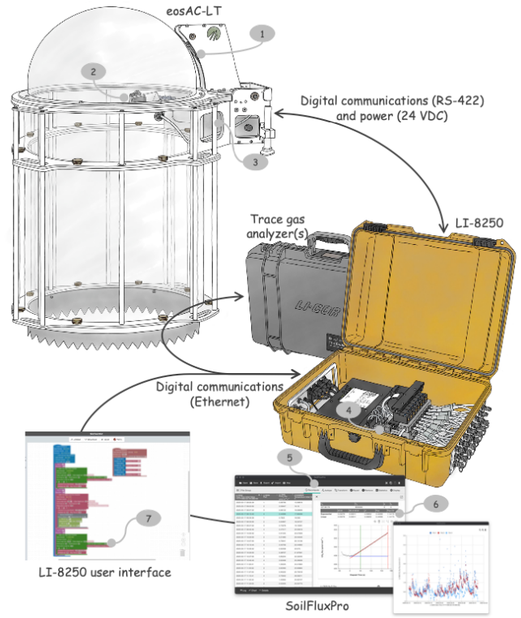
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Measurements of plant mediated fluxes of trace gases (e.g. methane and nitrous oxide) are possible through a variety of methods that operate over a range of spatial scales. For measurements constrained to the canopy scale, use of large (one to a few cubic meters in volume) closed-transient chambers has been common. Uncertainty in closed-transient chamber measurements can be introduced from a number of sources, many of which are a direct product of the chamber or sampling system design. Lack of a single source manufacture for all components necessary to make canopy-scale closed-transient chamber measurements has meant that historically these measurements have required engineering effort on the part of the researcher to achieve. This has ranged from researcher-built measurement systems where some to all components, beyond the gas analyzer(s), were custom designed and built by the researcher. While this has spurred innovation advancing this area of research, lack of standardized tools and data processing platforms has been a key source of uncertainty in these measurements. This has also meant that canopy-scale measurements have been limited to only research programs with adequate engineering resources to construct and operate such systems. Here we describe integration of two different commercially available systems. The integrated system provides a complete off-the-shelf solution for canopy scale trace gas flux measurement. The combined system integrates a large canopy chamber (Eosense, eosAC-LT) with a gas sampling/analysis/data processing system (LI-COR, LI-8250, LI-78xx and SoilFluxPro). We demonstrate both hardware and software integration, including data processing, and performance of the combined measurement system.





GT 03 - 895 - P

THE BEHAVIOUR OF MICROBIAL COMMUNITIES IN SOILS WITH DIFFERENT VEGETATION COVERON KING GEORGE ISLAND (MARITIME ANTARCTICA).

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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The Northern Antarctic Peninsula Region, in particular the coastal areas are undergoing substantial melting, and the ice-free areas that are exposed are vulnerable to colonisation by microbial populations and plant species. During the Antarctic summer, optimal conditions for plant and microbiological development in the soil contrast with the ice or permafrost during the winter, preventing the development of woody vegetation in Antarctica. Thus, in the summer, we find two types of vascular plants and cryptogamic plants (mosses and lichens), forming patches of vegetation in more humid areas resulting from summer thawing. In this study, our objective is to characterise, at a taxonomic and functional level, the microorganisms that develop in these patches of vegetation and in bare soils, where ecological development slows down and speeds up depending on the season. For example, in climatic conditions with arid soils, the localised vegetation show significant differences in microbial taxonomic diversity (bacteria, fungi and archaea) compared to bare soils. Ecological indices (richness, Shannon, Pielou) reveal that taxonomic diversity is lower in areas with vegetation then in the bare soil, but functional diversity remains similar between the two environments. This suggests the existence of functional redundancy where different microbial taxa perform the same key ecological functions (e.g., C and N cycles). On the other hand, the assembly of microbial communities, which depends on deterministic and stochastic processes, differentiates these two environments. The predominance of deterministic processes in areas with vegetation suggests selective pressure from certain bacterial phyla. Thus, in areas with vegetation cover, a predominance of phyla is observed: Proteobacteria, Bacteroidota, Myxococcota in bacteria and Crenarchaeota in archaea; contrasting with the dominant phyla of bare soils, which are more diverse and contain: Chloroflexi, Gemmatimonadota in bacteria, Thermoplasmatota in archaea, and Mortierellomycota, Basidiomycota and Chytridiomycota in fungi. Future studies will allow for a deeper understanding of functional redundancy, as well as the resilience and resistance of microorganisms present in the different environments. Understanding how these microorganisms maintain their functionality under extreme conditions and environmental disturbances will contribute to predicting the ecological stability of these ecosystems and developing strategies for their conservation in a context of global climate change.

GT 03 - 904 - P

SOIL TEXTURE AND DROUGHT DYNAMICS SHAPE THE RHIZOSPHERE ECONOMY OF MAIZE LANDRACES AND HYBRIDS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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A comprehensive understanding of crop strategies for soil resource acquisition is critical for achieving sustainable food security as climate change progresses. Root and rhizosphere traits play a central role in the acquisition of water and nutrients, yet the variety-specific rhizosphere strategy, its plasticity and adaptation to drought remain largely obscure. Here, we aimed to address this knowledge gap by investigating the phenotypic root and rhizosphere trait combinations across two contrasting belowground strategies (do-it-yourself vs. outsourcing) in maize (Zea mays L.). The maize varieties were grown in two soils with different textures (loamy vs. sandy), each under five distinct water availabilities: optimal (1), moderate (2) and low (3) water availability throughout the entire growth period, plus a reciprocal approach with either a dry-down phase of optimally watered plants (4) or water addition to plants with initially low water availability (5) shortly before sampling. In a controlled greenhouse experiment, six maize varieties were grown; three of them showed increased specific root length, decreased association with mycorrhiza and decreased root-derived C signals in the rhizosphere soil (do-it-yourself strategists), and the other three exhibited increased mean root diameter and arbuscular mycorrhization as well as increased specific rhizosheath mass (outsourcing strategists) in a previous experiment. Preliminary results showed that specific rhizosheath mass (rhizosheath mass normalized by root length) was highest in plants exposed to drought at the beginning and irrigated towards the end of the experiment and particularly in the sandy soil. Further results will be presented, obtained by multivariate statistics, to evaluate which rhizosphere strategies are most effective depending on soil texture and how they adapt to contrasting and changing water availabilities.



GT 03 - 929 - P

POST-FIRE SOIL RECOVERY AFFECTED BY SOIL DEPTH AND FIRE SEVERITY ALONG A LONG-TERM CHRONOSEQUENCE IN A CENTRAL EUROPEAN TEMPERATE FOREST

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Wildfires are currently becoming a global threat to forest ecosystems, affecting not only vegetation, but also key soil properties. Here we provide first insights into the long-term post-fire dynamics of soil properties as related to soil depth and fire severity in a Central European temperate forest. In this study, we investigated changes in soil physical, chemical and microbial properties in Scots pine-dominated forests along a unique 110-year-long post-fire chronosequence. We collected soil samples from the organic (O) and the surface mineral (0–5 cm; A) horizons affected by wildfire of either high or low severity. We show that the time needed to recover after the fire was longer for the physical and chemical properties (< 110 years) than for the microbial properties (< 45 years). Although the relative change in soil properties was larger in the A horizon than in the O horizon (60% vs. 46%), the absolute change determined the recovery time. The recovery time was therefore longer in the O horizon (< 110 years) than in the A horizon (< 9 years). Our data also indicate that the young sites showed significant effects of fire severity, with longer recovery times after high severity fires. Although the effects were only found in microbial properties, indicating their high sensitivity to fire, the differences clearly show that the O horizon is rather prone to fire severity, whereas the A horizon is relatively resilient.

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GT 03 - 946 - P

SMALL HIDDEN WETLANDS: ECOLOGICAL ROLE OF WATERLOGGED ORGANIC SOILS IN NORTHERN SPAIN'S MONTAÑA PALENTINA (CANTABRIAN MOUNTAIN RANGE)

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Peat-rich soils (Histosols) play a fundamental role in carbon sequestration, hydrological regulation, and biodiversity conservation. While typically associated with extensive peatlands, similar ecological conditions, such as persistent water saturation, low oxygen, and organic matter accumulation, also occur in much smaller, less conspicuous settings. These localized waterlogged organic soils form in depressions, seepage zones, and other high-moisture microenvironments, and are often overlooked in soil surveys and conservation planning. This study focuses on such environments in Brañosera, Montaña Palentina (Cantabrian Mountains, northern Spain), a humid upland area characterized by a mosaic of forests, pastures, and heathlands. We aimed to assess the ecological significance of small organic wetland patches embedded in this landscape. Remote sensing tools (high-resolution orthophotos, slope models) were combined with expert-based interpretation of vegetation and topography. Field visits confirmed saturated soils, the development of organic horizons, and the presence of hydrophilic plant communities. We identified well-preserved peatland systems (e.g., Sel de la Fuente) and scattered micro-wetlands in meadows and heathlands. Although small, these micro-wetlands typically cover very limited areas (often around 100 m² per hectare, representing just 1% of the land surface), yet their ecological relevance is disproportionately high. These patches act as hotspots for carbon storage, water retention, and biodiversity. Their occurrence is linked to siliceous lithologies, gentle slopes, and microtopographic variations. These enclaves enhance landscape resilience but remain vulnerable to drainage, land-use change, and climate shifts. Recognizing and protecting these hidden ecosystems is essential for sustaining soil functions and biodiversity.

ACKNOWLEDGEMENTS

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GT 03 - 947 - P

TREE SPECIES PROPORTIONS MODULATE NUTRIENT COMPOSITION ACROSS FOREST LITTER LAYERS IN MIXED STANDS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 02. SOIL PHYSICAL CHEMISTRY

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Mixed-species forests are increasingly valued for their multifunctionality and potential to enhance ecosystem resilience. However, how species composition affects litter elemental composition and decomposition dynamics remains underexplored across biogeographic contexts. This study evaluated how mixtures of Pinus sylvestris with Fagus sylvatica or Quercus petraea influence nutrient dynamics in decomposing forest floor layers. Fieldwork was conducted in four mountainous regions: the Cantabrian Range and the Pyrenees (Spain), Niepołomice Forest (Poland), and Schrobenhausen Forest (Germany). In total, 266 composite litter samples were collected from pure and mixed stands and analyzed for total contents of C, N, P, S, Ca, Mg, K, Fe, Mn, Zn, and B across three litter layers: L (fresh), F (partially decomposed), and H (humified). Litter from mixed stands was sorted by species in the L and F layers; H layer samples remained unsorted due to advanced decomposition. We applied generalized linear mixed models (GLMMs) to test the effects of forest type and litter species on nutrient concentrations, using litter layer as a repeated factor and site as a random effect. The proportion of pine in each mixture (pine_share) was included as a continuous covariate. While the quadratic term of pine_share showed no significant effects, its linear component significantly explained variation in multiple nutrient variables. This suggests that nutrient composition responds gradually to pine dominance, reinforcing the value of continuous over categorical predictors. Results showed that mixed stands, particularly those including beech, enhanced nutrient retention in deeper litter layers and promoted more balanced micronutrient profiles. Higher proportions of broadleaf litter correlated with increased concentrations of Ca, K, and N. These patterns likely reflect differences in litter quality and decomposition rates among species, modulated by local site conditions. In terms of decomposition dynamics, our findings suggest species-specific interactions. Broadleaf litter inputs appeared to stimulate pine needle decomposition at advanced stages (H layer), possibly due to improved nutrient availability or microbial activity. Conversely, the decomposition of oak litter was inhibited in the presence of pine needles during intermediate stages (F layer), while beech litter showed little evidence of inhibition, indicating greater microbial tolerance to conifer-derived material. These contrasting effects underscore the complexity of species interactions in litter mixtures. This study highlights the need to consider species-specific effects and continuous composition gradients in silvicultural planning to optimize nutrient cycling, soil function, and forest ecosystem resilience under global change scenarios.

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GT 03 - 950 - P

CHARACTERIZATION BY THERMAL ANALYSIS OF SOIL ORGANIC MATTER STORAGE INDUCED BY ORGANIC AMENDMENTS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Due to the increasing societal demand for the development of renewable energy sources and CO2 mitigation, new agricultural practices are emerging, such as anaerobic digestion to produce biogas, soil conservation agriculture, and the advancement of organic matter treatment through pyrolysis. These novel practices result in the reintroduction of more biomass (cover crops), along with various organic residual organic matters (anaerobic digestion digestates, organic waste compost, biochars), may induce Soil Organic Carbon (SOC) sequestration. Soil Organic Carbon (SOC) sequestration can contribute to partly offsetting greenhouse gas emissions, and mainly to increased soil quality and climate change adaptation (Rumpel et al., 2020). Thus, there is a need for credible and reliable measurement/monitoring, reporting and verification platforms, both for national reporting on SOC storage, soil quality and for emissions trading (Smith et al., 2020).

The Rock-Eval® thermal analysis is recognised for a range of applications, including the characterisation of hydrocarbons in solid rocks, petroleum products and sedimentary rocks. Its use to characterise the nature of Soil Organic Matter (SOM) is also being developed, particularly for agronomic and environmental purposes. In this context, the originality of this study consists in using the Rock-Eval tool to explore its potential to characterise the nature of residual organic matters (silage maize, silage maize after anaerobic digestion, silage maize after pyrolysis), and then SOM after the addition of these residual organic matter. The results of these characterisations are interpreted in the light of soil respiration measurements. Soil respiration measurements enabled us to trace residual organic matters and SOM decomposition during a laboratory incubation, using 13C-CO2 as a tracer of organic matter. Durability and significance of the SOC storage in soils depend on the biological decomposition/stability of organic amendments and SOM.

Using the I-index of the Rock Eval® analysis, we determined that silage maize and digested silage maize decomposition mechanisms in soils resulted in the selective decomposition of biological tissues (Figure 1). Results also highlight that the use of the soil I and R -index is restricted to the study of the stability of Organic Matter (OM) and excludes carbonaceous matter such as biochar (Figure 1). This experiment gives insights on the potential use of I-index to predict Corg storage after the addition of organic amendments. This exploratory study opens up promising avenues of research for the development of agronomic and environmental quality indicators for organic amendments and SOM based on Rock-Eval® analysis.

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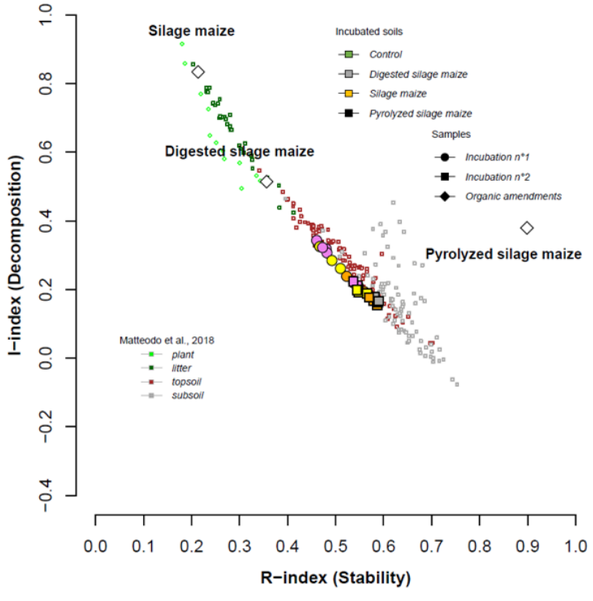


Figure 1. Positioning of organic products and incubated soils as a function of the I and R -index relative to measurements made by Matteodo et al. (2018).

GT 03 - 961 - P

INTERANNUAL DYNAMICS OF SOIL ORGANIC FRACTION AND BIOLOGICAL ACTIVITY IN ABANDONED MEDITERRANEAN AGROSYSTEMS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Vineyards are a traditional Mediterranean crop that, in recent decades, has been abandoned on the European continent due to socio-economic and ecological factors. This abandonment has been particularly evident in Spain, where the area dedicated to vineyards has been reduced by 34.6% between 1999 and 2015. Following the process of abandonment, the plots are colonised by native vegetation, thereby initiating the process of secondary succession. In that sense, the Mediterranean climate is characterized by intra- and inter-annual variability which has significant ramifications for the functioning of ecosystems, the services they provide and the success of the secondary succession evolution. The hypothesis of this study is that inter-annual climatic variability, a characteristic feature of the Mediterranean climate, determines soil functionality and, consequently, the ecosystem services provided by abandoned ecosystems. The objective of this study is to demonstrate how interannual climate variability exerts a substantial influence on soil functionality, which will exhibit divergent dynamics contingent on the age of abandonment of the agrosystems. In order to achieve this objective, permanent plots were established in 2016 in a chronosequence of abandonment, where the physico-chemical and biological properties of the soils were monitored on an annual basis.

The chronosequence constructed in 2016 comprised eight plots, of which six exhibited abandonment ages of 1, 3, 7, 11, 25 and 40 years, respectively. In addition, the sequence incorporated an active vineyard and a plot that had never been cultivated. In these plots, three squares of 1x1 m were established in which the annual monitoring of the soils has been carried out every spring (the period of maximum vegetation development) in nine consecutive years. A total of 24 samples were analysed on an annual basis, with the objective of determining total organic matter and 12 soil enzymatic activities related to the main nutrient cycles (C, N, P and S).

The results showed that inter-annual climate variability exerted a significant influence on the response of the abandoned ecosystems. The factors driving the biological response of the soil were temperature and precipitation independently of the years of abandonment of the plots. Specifically, temperature anomalies were positive in all seasons of the nine-year study period years, with the exception of spring 2016 which exhibited a 0.1 °C decrease compared to the historical average. The variability in rainfall could be the determining factor of the response, since clearly the trends in all the plots, regardless of the age of abandonment of the same followed trends closely related (either negatively or positively) to periods of drought. This is especially relevant to the time of year in which they occur. The effect of spring drought events, which coincide with the period of maximum development of the annual pastures studied, was very negative.



GT 03 - 969 - P

GRASSED VINEYARDS BENEATH CLIMATE CHANGE (CUBIC PROJECT)

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 09. SOIL HEALTH

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Climate change is one of the most serious global challenges of our time. The increase of temperatures and shifting weather patterns are altering ecosystems worldwide. Soil plays a crucial role in both human and planetary health, but this scenario is accelerating soil degradation due to increased droughts and flooding. These changes directly impact agricultural productivity and crop quality. Farmers are facing unpredictable growing seasons and declining yields, making it urgent to adapt farming practices and safeguard food security. As a result, interest in soil conservation has grown, and many hypotheses are being proposed about how this problem may evolve if global temperatures continue to increase.

The present project aims to evaluate the performance of woody crops (vineyards) under different soil management strategies, simulating a temperature increase of approximately 2ºC above current ambient conditions. Vineyards are an important economic sector in many Mediterranean countries, where soil degradation is particularly severe; therefore, it is essential to estimate potential impacts if climate issues continue to escalate. The studies will be conducted on young and mature vines (20 years old), focusing on the two most widespread grape varieties in Spain: Airén and Tempranillo, located in Madrid (Spain). These varieties are managed under two systems: traditional tillage and cover crops. Open-top chambers will be used to simulate increased temperatures. Over two full years, the research team will assess multiple aspects of the system: soil and plant water dynamics, vine phenological stages and wine production, soil organic carbon quantity and composition, soil microbial community responses, and the performance of different legume cover crops.

Currently, there are few field-based studies that examine the full range of potential climate change effects on the soil–plant system and final product quality. This project seeks to clarify how climate change may affect vineyards under different soil management practices. Understanding these effects is critical for predicting and preparing for future warming.

ACKNOWLEDGEMENTS

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GT 03 - 983 - P

THE ROLE OF SOIL FACTOR IN LAND USE TRANSITIONS IN MARGINAL REGIONS OF THE EASTERN BALTICS: A CASE STUDY OF LATVIA

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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In the marginal regions of the Eastern Baltics, soil properties have been identified as the driving force behind land-use transitions, thereby amplifying the impact of social, economic, and political factors. The study was conducted in a 318-hectare area of the Latgale Upland in Latvia, which underwent substantial land-use changes between 1954 and 2021. In this marginal landscape, land-use change followed a trajectory from arable land to grassland, and later to forest on former agricultural lands. These transitions, driven by agricultural extensification, land abandonment, and natural afforestation, were influenced by underlying soil properties. In recent years, the replacement of grassland with fallow land has become increasingly evident, driven by European Union direct payments and the associated eligibility requirements. The objective of the study was to examine the relationship between soil properties and land-use trajectories.

Multinomial logistic regression analysis across the entire study period indicates that land quality has been one of the most significant drivers of land-use change. Historically, during the Soviet era, land use was strongly influenced by land quality, as it was one the factors that determined regional specialization. Our findings shows that less fertile soils, particularly sandy or peat soils, were more likely to be abandoned and subsequently undergo natural afforestation, whereas grasslands tend to persist on more fertile, fine-textured soils. However, recent trends show a shift, with fertile, high-potential agricultural soils increasingly being afforested, likely due to climate policies and carbon sequestration incentives.

Principal component analysis identified distinct soil fertility and texture gradients across land-use transitions. Soil analyses across different land-use scenarios revealed that grasslands, especially those with a legacy of intensive use, retain higher pHKCl values and concentrations of total organic carbon (TOC), organic nitrogen, and exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}) compared to forested areas. Naturally afforested sites were characterized by lower soil fertility, indicating that forest development occurred not only on inherently less productive soils but also contributed to further nutrient depletion through tree root uptake. These findings reflect the complex interplay between historical land management practices and inherent soil properties in shaping long-term land-use trajectories.

In conclusion, the study findings highlight the critical role of soil properties in shaping land-use trajectories and underscore the necessity of integrating soil factors into land-use planning and policy to develop evidence-based, context-sensitive strategies that balance afforestation goals with the conservation of productive agricultural lands and support the long-term sustainability of rural landscapes.



GT 03 - 985 - P

ASSESSMENT OF BIOPHYSICAL FACTORS INFLUENCING LAND-USE IN HETEROGENEOUS LANDSCAPES OF LATVIA

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Understanding the influence of biophysical factors on land-use dynamics is essential for sustainable landscape management, particularly in environmentally heterogeneous regions. The aim of the study is to identify the biophysical factors that determine whether land is used as cropland, grassland, or abandoned land across different predominant landscapes in Latvia.

This study examines land-use patterns across Latvia's diverse landscapes. To capture environmental variability, four predominant landscape types—upland, plain, polder, and undulated—were investigated, with three representative ecoregions selected within each landscape type. A randomized grid of 25 843 points was generated across these landscapes. Data were collected at each point, including soil type, classified as mineral soil, shallow peat soil (30–60 cm), and deep peat soil (> 60 cm), drainage system type (categorized as closed, open, or not drained), land quality index, and average land block size (ha). These variables were analysed using factor analysis to determine their influence on agricultural land-use outcomes in 2024, classified into three categories: cropland, grassland, and abandoned land.

Cropland is primarily found in areas with favourable biophysical conditions and well-developed drainage infrastructure, regardless of the landscape type. This pattern is strongest in upland, undulated, and polder landscapes, and remains evident in the plains. Cropland typically occupies flatter terrain and larger field parcels in upland and undulated areas, reflecting more intensive and economically viable agriculture. In polder regions, cropland is frequently located on deep peat soils, while in plains it is linked to higher land quality, despite the prevalence of sandy soils and forested areas. In contrast, abandoned land is concentrated in marginal areas with poor accessibility, limited drainage, steeper slopes, particularly in upland and undulated landscapes, and smaller, fragmented parcels. In the plains, abandonment is further associated with lower soil quality. Grassland is typically found on moderately sloping terrain, at intermediate distances from drainage infrastructure, and on fields of average size and land quality. This finding suggests that grassland functions as a transitional land-use, which is common in areas unsuitable for intensive cultivation but not yet abandoned. The intermediate conditions of the site indicate its vulnerability to future land-use change, which may take the form of either re-cultivation or succession to abandonment. Furthermore, a discussion on the use of peat soil in large landscapes is now imperative, involving both biophysical and socio-economic aspects.

Based on the results, this study underscores the critical need to account for landscape-specific biophysical heterogeneity in land-use planning and policy to enhance the sustainability of agricultural practices and mitigate land abandonment in environmentally sensitive areas.

GT 03 - 986 - P

NITROUS OXIDE (N_2O): AGRICULTURAL EMISSIONS AND CLIMATE IMPACTS. THE MITIGATION STRATEGIES ACCORDING TO THE HOLOSEU AS DIGITAL PLATFORM FOR LAND USE PLANNING

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Nitrous oxide (N_2O) is the third most important anthropogenic greenhouse gas, with a global warming potential (GWP_{100}) of 298 relative to CO_2. Despite its relatively low share in total GHG emissions by volume, its high radiative efficiency and long atmospheric lifetime (~120 years) make it a critical target for climate mitigation strategies.

The main source of N_2O is soil microbial activity, intensified by human practices-particularly the use of nitrogen-based fertilizers in agriculture. According to the EDGAR 2024 database (https://edgar.jrc.ec.europa.eu/report_2024), agricultural N_2O emissions in the EU27 reached approximately 500 kilotonnes, corresponding to about 0.13 Gt CO_2eq. This causes that agriculture is responsible for over 70% of anthropogenic N_2O emissions in the EU. While emissions from grasslands and forests are significantly lower, they remain important due to their large spatial coverage and ecological role. The LULUCF sector continues to be a net carbon sink in the EU, with – 236 Mt CO_2eq in 2022.

Mitigation strategies in agriculture include optimizing nitrogen fertilization, precision application methods, and the use of nitrification inhibitors. In grassland and forest systems, measures focus on protecting organic soils, avoiding drainage, and maintaining permanent vegetation cover. In forests, strategic planning of clearcuts, afforestation, and avoiding habitat degradation are key.

An integrated approach to N_2O mitigation should combine agronomic best practices, effective climate policy tools, and education for land users. Reducing N_2O emissions not only supports climate targets, but also improves nitrogen use efficiency and helps safeguard soil and water quality. As agriculture, beside GHG emissions, becomes increasingly vulnerable to climate change, implementing effective N_2O mitigation measures is a growing priority for sustainable land management.

To address the current climate challenges at farm level, the HOLOSEU project was launched. The project aims to develop a digital platform to support land-use planning and decision-making in European agriculture. One of its key objectives is to assess GHG emissions from agricultural soils under different land-use types (including arable fields with mineral and organic fertilization, grasslands, pastures, and agroforestry systems) for model validation and calibration.

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GT 03 - 987 - P

HOW CAN AGROFORESTRY REGULATE GREENHOUSE GAS EXCHANGE IN AGRICULTURAL SOILS?

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Agroforestry is a very ancient agricultural practice that refers to the intentional integration of woody perennials (such as trees and shrubs) with crops and/or livestock within the same land management unit. Trees may be established within agricultural fields or positioned along field boundaries, such as in the form of hedgerows. Agroforestry systems offer a wide range of environmental benefits at multiple levels. They help regulate the microclimate, improve soil moisture and water retention, reduce erosion, boost biodiversity, and enhance carbon sequestration. It also improves livestock welfare through the use of trees in pastures (e.g., the dehesa system). Since agroforestry can be used in nearly every type of farming environment in Europe, the EU encourages and supports farmers who choose to adopt this approach.

At the same time, the agricultural sector is a significant source of greenhouse gases (GHG) with a high amount of emissions from fertilized soils. Considering the EU strategies taking into account the reduction of GHG emissions by 2050, it is necessary to adopt mitigation practices and sustainable management of agricultural systems. Implementing agroforestry at the farm level can be a practice to help reduce soil GHG emissions by different mechanisms, e.g., improving soil structure, increasing the input of organic matter, reducing water and nitrogen loss, improving nitrogen use efficiency (selected species of tress) and increasing porosity and soil oxygenation by tree roots that cause lower N2O emission and increase CH4 uptake (methanotrophic activity). By changing the physico-chemical parameters of soils, agroforestry also influences their biological activity, including microorganisms involved in GHG exchange.

The many environmental and economic benefits of implementing agroforestry systems make them considered one of the most viable options for climate change adaptation and mitigation. Hence, their more precise impacts on edaphic conditions and GHG emissions were included in the HOLOSEU project research.

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GT 03 - 1008 - P

QUANTIFYING CARBON RESPIRATION IN URBAN GREEN ROOF SYSTEMS AND VEGETATION TYPES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Green roofs increase urban green space and offer environmental benefits such as air purification, heat island mitigation, and biodiversity enhancement. They also contribute to carbon neutrality by absorbing atmospheric carbon and reducing building energy use through improved insulation. However, carbon dioxide emissions from soil respiration must be quantified to accurately assess their net carbon reduction effect.

This study aimed to evaluate soil carbon respiration on green roofs by conducting field-based monitoring across four rooftop sites-three located in Seoul and one in Goyang, South Korea. These sites represented a range of greening types, including extensive, semi-intensive, and intensive systems. Vegetation types varied from mono layered herbaceous planting schemes to more complex, multi layered compositions that incorporated shrubs and small trees. Over a six-month period, measurements of soil carbon respiration were conducted using a portable CO_2 gas analyser (EGM-5), in combination with environmental data including soil and air temperature and humidity.

Cumulative soil respiration was calculated for each site, and its relationship with soil temperature and moisture was assessed. The analysis revealed variation in soil carbon respiration based on differences in effective soil depth, vegetation type, green roof system design, and maintenance practices. In particular, higher respiration rates were observed in sites with crop plantings or complex vegetation layers indicating a tendency for increased carbon emissions under such conditions.

These findings improve our understanding of carbon emissions from green roof soils and support the development of low carbon green roof technologies and maintenance guidelines. Furthermore, they provide a foundation for evaluating the effectiveness of urban green roof policies and informing carbon reduction strategies for local governments.

ACKNOWLEDGEMENTS

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GT 03 - 1009 - P

SOIL CARBON DYNAMICS UNDER DRYING–REWETTING CYCLES: AN ACCURATE QUANTIFICATION OF THE BIRCH EFFECT UNDER CONTRASTING SOIL TEXTURES AND LAND MANAGEMENT

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Climate projections predict an increased frequency of extreme precipitation and drought events in temperate agroecosystems, leading to more pronounced drying–rewetting (D–W) cycles. These moisture fluctuations trigger pulses of CO_2 emissions from soil microbial activity—commonly known as the Birch effect—which may destabilize soil organic carbon (SOC) stocks. Yet, large variability in the magnitude of this response persists across studies, suggesting a strong influence of soil properties and land management but also a variability caused by differences in methodology (no continuous CO2 measurement, inconsistent control treatments).

We conducted a controlled incubation experiment on undisturbed soil cores from three French agricultural sites with contrasting textures (sandy, loamy, clayey) and management (conventional cropping, organic farming, conservation agriculture and permanent grassland,). Soils were subjected to (i) five simulated D–W cycles (1-week drying, 1-week rewetting), (ii) a continuously moist scenario at pF2, and (iii) a novel control where each soil's mean water potential over a D–W cycle had been directly established (pFx). Emitted CO2 as measured continuously, including during drying phases. This approach, rarely implemented, allowed for an unbiased comparison of cumulative carbon mineralization across hydric regimes.

Our results revealed that all soils exhibited a CO2 peak when rewetted, with decreasing amplitude with the numbers of cycles, with an amplitude affected by both soil texture and land management. However, when comparing cumulative C-CO_2 emissions under D–W cycles with pFx moisture control, no significant over-mineralization (net Birch effect) was detected in clayey soils, regardless of land use, nor in silty soils under conservation agriculture and grassland. This result suggests a potential buffering effect of finer textures and of aggregate stability. Yet, in medium-textured soils, conventional agricultural practices and organic systems, and coarse texture soils under conventional agriculture and grassland led to significantly higher cumulative C-CO_2 emissions under D–W cycles compared to pFx moisture control.

These findings support the hypothesis that both microbial and abiotic mechanisms contribute to the Birch effect, with their relative importance influenced by texture and management. Recurrent D–W events may lead to progressive depletion of labile C and destabilization of protected carbon pools, with implications for soil C persistence under future climate scenarios. Our work underscores the need for mechanistic understanding of the Birch effect, to improve its prediction according to soil characteristics, land use and management and promote is accounting for in SOC dynamics models.

KEYWORDS

Drying–rewetting cycles, Birch effect, Soil texture, Land use, agricultural management, Carbon mineralization, Soil organic carbon, Climate change

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GT 03 - 1010 - P

MODELLING THE EFFECT OF KEY MICROBIAL PROCESSES ON THE BIRCH EFFECT DURING A SOIL DRYING-REWETTING CYCLE.

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The sharp increase in C-mineralization following the rewetting of dry soils—known as the Birch Effect—is thought to result notably from microbial processes such as osmoregulation, dormancy, mortality and continuous depolymerization [1]. However, the interplay of these processes and their dependence on factors like drought duration and intensity remains difficult to disentangle through experiments alone, limiting our mechanistic understanding of the phenomenon.

Modelling offers a powerful tool to explore these interactions and test the contribution of individual processes under controlled scenarios. While existing 0-D models account for some microbial mechanisms thought to drive the Birch Effect [2], they generally overlook the spatial organization of microbes and organic substrates within the soil matrix—an aspect considered critical for regulating heterotrophic respiration [3].

Here, we present a novel 3D microscale model that explicitly simulates heterotrophic respiration during a drying–rewetting cycle, integrating the physical structure of soil microhabitats. The model incorporates key microbial processes (dormancy, mortality, osmoregulation) and considers scenarios with or without continuous depolymerization during drought for two drought intensities (moderate: 1 week; severe: 6 weeks). Soil structure and particulate organic matter are spatialized using 5.6 µm-resolution microtomographic images of clayey soil aggregates [4]. Three physiologically distinct bacterial species are represented as non-motile, spatially explicit competitors, distributed via a Log-Gaussian Cox Process (LGCP) [5]. The model couples a Lattice-Boltzmann method for water phase and solute diffusion with a biogeochemical carbon model, capturing the detailed pore geometry, microbial arrangement, and organic matter distribution.

Simulations indicate that the CO_2 pulse upon rewetting increases with drought duration, likely due to a higher accumulation of microbial derived products from mortality and continuous depolymerisation. Osmoregulation has a moderate overall effect on respiration dynamics.

This 3D modeling framework offers a promising tool to disentangle the role of microbial processes in shaping the Birch Effect. It highlights the protective role of dormancy, which reduces mortality-driven carbon release, and underscores how sustained depolymerization during drought can amplify post-rewetting respiration.

Keywords: Birch effect, Microscale modeling, Microbial stress response, Soil pore geometry, Heteretrophic respiration, Carbon cycling

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GT 03 - 1011 - P

EFFECTS OF NITROGEN FERTILISER TYPE AND ORGANIC AMENDMENTS ON SOIL N_2O EMISSIONS IN WINTER WHEAT IN THE UK

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Winter wheat production in the UK relies on substantial nitrogen (N) inputs [1], a major source of agricultural nitrous oxide (N_2O) emissions. Emissions may be intensified by organic amendments such as farmyard manure (FYM) [2], and the use of organo-mineral fertilisers (OMFs) as alternatives to conventional ammonium nitrate (AN) [3]. Both FYM and OMFs introduce further complexity on estimating N_2O emissions as empirical evidence remains limited on how these inputs interact and influence N_2O emissions under field conditions.

A factorial field experiment was conducted with winter wheat to assess the effects of FYM (+FYM vs -FYM), N fertiliser type (AN vs OMF), and fertiliser N application rate (0, 80, 160, 240 kg N ha^{-1}) on direct soil N_2O emissions. Soil GHG fluxes and abiotic variables were monitored at daily to fortnightly frequencies with portable GHG analysers from pre-sowing to harvest. Aboveground biomass and yield components were estimated with harvest samples.

Key findings:

1. Early N_2O emissions driven by FYM: Application of 22 t ha^{-1} FYM (155 kg total N ha^{-1}) significantly increased N_2O fluxes prior to fertiliser application, by an average of 698% (~1500 g N_2O-N ha^{-1}) in cumulative emission. Spikes in N_2O flux occurred primarily within the first eight weeks after FYM incorporation, likely due to elevated soil moisture and N availability.

2. Limited effect at low to moderate N rates: At 0, 80, and 160 kg N ha^{-1}, neither FYM nor fertiliser type significantly affected cumulative N_2O flux.

3. Interaction between FYM and OMF at high N rate: At 240 kg N ha^{-1}, the combination of FYM and OMF increased cumulative N_2O fluxes compared to other treatments. Cumulative N_2O flux of OMF+FYM was significantly higher ($p < 0.05$) than those of OMF-FYM and AN+FYM, and marginally higher than that of AN-FYM.

These findings highlight that at high N rates, the combined use of FYM and OMF can result in synergistic increases in N_2O emissions. Additionally, manure application alone could contribute substantially to early-season emissions. Given the widespread use of manures and the growing adoption of OMFs in UK arable systems, understanding their interactions is critical for effective and climate-conscious N management.

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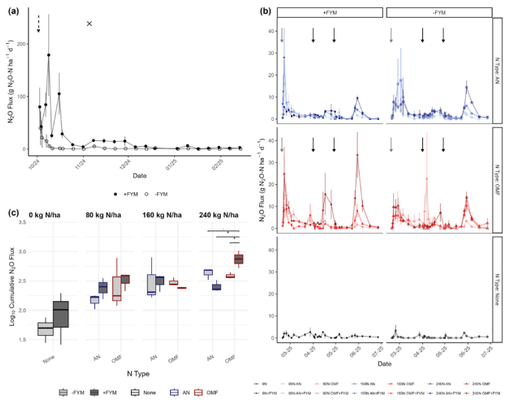
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(a) N2O fluxes following cattle farmyard manure (FYM) application (22 t fresh weight ha?¹) and prior to any manufactured fertiliser inputs. (b) N2O fluxes from the first mineral fertiliser application until harvest, under factorial combinations of fertiliser type (ammonium nitrate [AN; blue squares], organo-mineral fertiliser [OMF; red triangles]) and FYM treatment (+FYM: filled symbols; –FYM: open symbols), across four N application rates (0, 80, 160, 240 kg N ha?¹). Dashed arrow in (a) indicates the FYM incorporation date; cross indicates sowing of winter wheat (cv. Extase; 400 seeds m?²). In (b), downward arrows mark fertiliser application timings: grey (initial application of 40 kg N ha?¹ to all fertilised plots) and black (subsequent split applications at remaining rates). Points and error bars represent treatment means ± standard error (SE) across replicate field plots. (c) Cumulative N2O emissions (log10 scale) grouped by N rate, fertiliser type, and FYM treatment. Significant ($p < 0.05$) and marginal ($p < 0.1$) pairwise differences are indicated by asterisks and dots, respectively.

GT 03 - 1013 - P

ELEVATED NUTRIENT CONCENTRATIONS AND NITROUS OXIDE LOSSES AS A RESULT OF TILLAGE REDUCTION PRACTICES

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 04. SOIL BIOLOGY

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Agricultural soils may play an important role as a carbon (C) sink to mitigate greenhouse gas emissions. Several strategies can be adopted to increase soil organic C stocks in arable soils, such as diversification of agroecosystems, increased input of C in the form of manure and soil amendments, or decreased disturbance of the soil. Practices aimed to increase soil C may however inadvertently lead to trade-offs in the form of emissions of other greenhouse gases, such as nitrous oxide (N2O), or enhanced nitrogen (N) and phosphorus (P) losses from fields. In this study, we sampled seven long-term European field trials on soil tillage across a pedoclimatic gradient. All experiments had a similar setup with treatments that included conventional tillage, reduced tillage, and no-till systems, each replicated four times, and a small grain crop was grown in each experiment before the sampling in fall. Soil samples were taken from the 0-10 cm and 10-20 cm layers, using a standardized approach, and analyzed for soil C, total and available N pools, as well as total, organic, and available P pools. In an incubation trial, N2O emissions and potential denitrification capacity were assessed. Results showed considerable variation among sites across all measured parameters. Reduction of tillage intensity generally increased soil C, but also soluble N (predominantly nitrate) and P concentrations in the 0-10 cm layer, likely due to a combination of reduced C breakdown and stratification of C and nutrient inputs, whereas those in the 10-20 cm layer were comparable across tillage treatments. Nitrous oxide emissions from the top layer were also elevated in treatments with reduced tillage intensity for five out of seven field trials. The same pattern, however, was less obvious for potential denitrification, with a larger variation among different sites. Our results point towards potential trade-offs in the form of nutrient losses and enhanced N2O emissions from the top soil, as a result of tillage intensity reduction to increase C stocks in agricultural soils. These side-effects should be taken into account when measures and policies are designed.

ACKNOWLEDGEMENTS

This research was conducted within the TRACE-Soils project and was financially supported by the European Joint Programme for Soil (EJP SOIL) (Grant agreement No 862695). This work was done in collaboration with numerous researchers from other European institutes: INIA, CSIC (ES), SLU (SE), INRAE (FR), Agroscope (CH), Aarhus University (DK), LAMMC (LT).



GT 03 - 1054 - P

THE LEGACY OF FIRE HISTORY IN MEDITERRANEAN ECOSYSTEMS: LONG-TERM IMPACT ON SOIL FUNCTIONALITY IN PINUS PINASTER AIT. FORESTS OF CENTRAL SPAIN

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Changes in land use and climate change can modify the forest fire regime by increasing fire frequency, severity or extent. These changes can significantly affect on ecosystem functionality, including both biogeochemical processes and the composition of soil microbial communities.

This work evaluated the effects of different fire histories - number of fires, time since the last fire (TSLF) and interval between the last two consecutive fires (TBF) - on the soil microbial functionality of Sierra de Gredos forests, originally dominated by Pinus pinaster Ait.). Soil samples were taken in areas that had burned zero, one, two and three times between 1976 and 2018, with TBF between 4 and 30 years and TSLF between 1 and 43 years. Both soil enzyme activities related to C, N, P and S cycles and the functional composition of fungal communities analysed by DNA sequencing and FUNGuild classification were evaluated in this study.

We found that fire had an immediate negative effect on soil enzyme activity and reduced the relative abundance of symbiont fungi, especially ectomycorrhizae. In contrast, saprotrophic and pathogenic fungi increased. However, over time, both enzyme activity and fungal functional composition tended to recover, reaching values similar to those of unburned soils after approximately 30-40 years. Neither the number of previous fires nor TBF showed significant effects on these variables.

In summary, the effect of the occurrence of fire prevails over the other variables related to the fire regime (number of fires or TBF). In addition, the resilience of the ecosystem, measured as the degree of recovery along TSLF, was not affected by the previous fire history.

ACKNOWLEDGEMENTS

This work was supported by the Spanish MCIN/AEI/10.13039/501100011033 and by the “European Union NextGenerationEU/PRTR” project (INFORICAM PID2020-119402RB-I00) and by UCLM and FEDER founding through the project 2023-GRIN-34447.

GT 03 - 1085 - P

DRIVERS OF SOIL NUTRIENT CYCLING AND GREENHOUSE GAS FLUXES ALONG A CLIMATIC GRADIENT IN NATURAL SHRUBLANDS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Natural shrublands, characterised by dense, evergreen woody vegetation and occasional short trees, are critical ecosystems for carbon storage, nutrient cycling, and biodiversity conservation. Despite their ecological importance and vulnerability to climate change, the responses of soil functions within these systems to changes in precipitation, temperature, and aridity remain poorly understood. This study investigated how climatic factors (soil temperature and moisture), together with key biotic (microbial diversity, plant cover, and richness) and abiotic variables (soil texture, pH), influence major soil functions across a regional aridity gradient ranging from humid to semi-arid conditions in Portuguese shrublands. We conducted seasonal sampling over two years across 23 plots to measure nutrient availability, extracellular enzyme activities, and greenhouse gas (GHG) fluxes (CH_4, CO_2, N_2O). Concurrently, we applied manipulative climate change treatments to experimentally assess whether significant shifts occur in drivers or soil functions.

Results showed that increasing aridity and temperature significantly reduced soil nitrogen availability, particularly during the summer. This reduction was associated with declines in plant cover and extracellular enzyme activities, suggesting intensified competition for nitrogen between plants and microbial communities. Interestingly, the activity of N-acetylglucosaminidase (NAG), an enzyme primarily involved in chitin degradation and nitrogen cycling, did not follow these seasonal patterns. Microorganisms may maintain more stable NAG production under climatic stress to access recalcitrant nitrogen sources when inorganic nitrogen becomes scarce, particularly under stress conditions like summer drought and heat. Phosphate availability in soils increased with aridity, likely associated with a predominance of the contribution of geochemical processes, such as mineral weathering, relative to biological demand, pointing to a decoupling of nitrogen and phosphorus cycling under drier conditions. Greenhouse gas fluxes exhibited a nonlinear response to aridity, with a threshold level identified at 0.6, beyond which the relationship between aridity and fluxes weakened or disappeared. This suggests that under extreme arid conditions, abrupt shifts in soil biogeochemical functioning may occur. The main factors modulating soil functioning at the plot scale were soil temperature, moisture, and pH, along with plant cover and microbial diversity.

These findings emphasise soil moisture as the primary limiting factor for soil functioning in natural shrublands and underscore the importance of local biotic and abiotic interactions in determining ecosystem stability to climate change. This study provides critical insights into how increasing aridity may alter nutrient cycling and greenhouse gas fluxes dynamics, with important implications for predicting the resilience of shrubland ecosystems under future climate scenarios.

ACKNOWLEDGEMENTS

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GT 03 - 1096 - P

EFFECTS OF ALFALFA–BARLEY INTERCROPPING ON CROP YIELD, RESOURCE USE EFFICIENCY, AND SOIL CHEMICAL AND BIOCHEMICAL PROPERTIES IN A MEDITERRANEAN AGROECOSYSTEM

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 09. SOIL HEALTH

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Legume–cereal intercropping offers a promising strategy for enhancing the sustainability of cropping systems in dryland regions, where adverse climatic conditions and prolonged cereal cultivation have led to declines in soil fertility and nutrient availability. A two-year (2023–2025) field experiment was conducted under rainfed conditions in semiarid central Spain to evaluate the effects of alfalfa–barley intercropping on crop yield, resource use efficiency, and soil chemical and biochemical properties. Treatments included alfalfa monoculture (no fertilization), barley monoculture (75 kg N ha^{-1}), and alfalfa–barley intercropping (37,5 kg N ha^{-1}), arranged in four randomized blocks.

Intercropping improved overall system performance, with Land Equivalent Ratios consistently >1, indicating more efficient land use compared to monocultures. Fertilizer equivalent ratios also exceeded 1, showing higher productivity under reduced N input. Despite a reduction in barley grain yield, total aboveground biomass was maintained in the intercrop, reflecting complementary resource use between species.

Soil analyses after the first growing season revealed improvements in soil biochemical and chemical properties under intercropping. Microbial biomass C and N increased, supporting enhanced nutrient availability. Intercropping also shifted microbial composition, significantly increasing arbuscular mycorrhizal abundance, which is linked to P uptake and soil aggregate stability. Lower microbial metabolic quotient (qCO_2) and respiration per unit of organic C (qM) indicated more efficient C use for long-term C stabilization. Enzymatic activities showed slight increases compared to barley monoculture, suggesting a trend toward enhanced microbial functioning. Intercropping also increased total N and organic C by ~14%, available $N–NH_4^+$ and $N–NO_3^-$ by ~16%, and decreased electrical conductivity by 14%, indicating improved nutrient retention and reduced salinization.

These findings highlight the potential of legume–cereal intercropping as a climate-smart and resource-efficient agricultural strategy to optimize land use and reduce fertilizer inputs. Although it reduced barley grain yield, the system maintained overall aboveground biomass, enhanced nutrient cycling, stimulated beneficial plant–microbial interactions, and contributed to C storage in semiarid agroecosystems.

ACKNOWLEDGMENTS

This research was supported by the **LEGUMINOSE project** (grant ref. 101082289).

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GT 03 - 1110 - P

SHADE TREE INFLUENCE ON SOIL CHEMICAL PROPERTIES, SOIL RESPIRATION AND ROOT DECOMPOSITION IN COSTA RICAN AGROFORESTRY COFFEE SYSTEMS

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Introduction: Agroforestry systems, particularly those integrating shade trees with coffee cultivation, are recognized for their potential to enhance ecosystem services and promote sustainable land management. While the benefits of shade on coffee productivity are well-documented, their long-term impact on soil biogeochemical cycles—critical for nutrient availability, carbon sequestration, and overall soil health—remains an active area of research. This study investigates the long-term effects of different shade tree species on soil chemical properties, soil respiration, and root decomposition in an established coffee agroforestry system in Costa Rica.

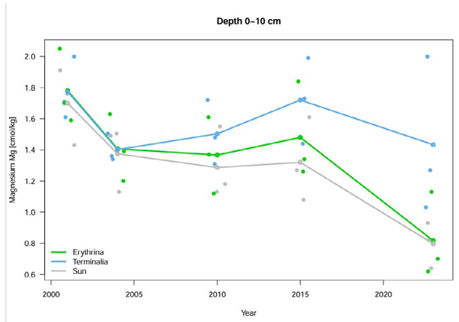
Materials and Methods: This study was conducted within a long-term field experiment established in 2000 in Turrialba, Costa Rica, on land previously under sugarcane cultivation. The experiment compares organic and conventional coffee production under various shade regimes. For this study, we focused on three treatments, all receiving moderate conventional fertilization: i) full-sun coffee (S), ii) coffee with Erythrina poeppigiana (E), and iii) coffee with Terminalia amazonica (T). A 6-week litter bag study was conducted in 2022 to assess fine root decomposition rates. Additionally, we analysed soil data (2001-2023) for changes in pH, magnesium (Mg), calcium (Ca), phosphorus (P), nitrogen (N) and carbon (C) content. Soil respiration measurements were conducted in July 2025 to assess microbial and root activity.

Results and Discussion: Our findings indicate significant differences in soil processes across the various shade treatments. The litter bag study revealed that fine root decomposition was slower in Terminalia amazonica (T) stands (22% weight loss) compared to the Erythrina poeppigiana (E) (32% weight loss) and full-sun (S) (37% weight loss) treatments. Concurrently, the T treatment exhibited higher pH, P, Ca, and Mg content than the other treatments, although N and C content showed no significant difference. Long-term data analysis (2001-2023) further showed a general decline in nutrient content and pH across all treatments, but this decline was less pronounced in the T treatment. For example, Mg in the T treatment decreased from 1.8 in 2001 to 1.4 in 2023, a slower rate of change compared to S (1.7-0.8) and E (1.8-0.8). Soil respiration measurements will provide insights into microbial activity, which may help explain the observed differences in decomposition rates. These results highlight the distinct impacts of different shade tree species on soil chemical properties and decomposition processes, likely influencing nutrient cycling and long-term soil fertility in coffee agroforestry systems.

Conclusion: Our study demonstrates that the choice of shade tree species significantly influences key soil biogeochemical processes in coffee agroforestry. The slower decomposition rates and more stable nutrient levels observed under Terminalia amazonica warrant further investigation into the underlying mechanisms, including microbial activity and recalcitrant litter quality. These findings contribute to a better understanding of how shade tree selection can be optimized for sustainable soil management in agroforestry systems.

ACKNOWLEDGEMENTS

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GT 03 - 1140 P

Influence of warming, redox dynamics and the application of exogenous organic matter on iron plaque mineralogy

GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Paddy soils are critical agroecosystems with significant roles in global carbon (C) cycling and food security [1]. However, warming and altered water management pose challenges to their productivity and soil organic carbon (SOC) stabilization. This study investigates how a moderate warming (+2°C), flooding regime variations, and exogenous organic matter (digestate) amendment affect iron (Fe) plaque formation and mineralogy on rice (Oryza sativa L.) roots, key drivers in SOC stabilization.

Root Fe plaques form under anaerobic conditions as oxygen leaks from roots, oxidizing soluble Fe(II) to precipitate Fe (oxyhydr)oxides. These plaques exert a “double-edged sword” effect on SOC: they can stabilize organic C by forming Fe-SOC complexes but also mediate soil organic matter (SOM) mineralization through Fe redox cycling [2]. Understanding how climate warming and soil amendments affect Fe plaque formation and function is essential to predict the fate of SOC and associated greenhouse gas emissions in paddy environments.

Material and Method:

The experimental setup employed open-top chambers (OTCs) to simulate a +2°C increase in temperature, with rice plants grown under two flooding regimes, normal flooding (NF) and reduced flooding (RF), and with or without digestate amendment (DS). Root samples were analyzed for Fe content, and grain yields were recorded at maturity. Root Fe concentrations varied widely across treatments (7.5 to 24 mg Fe/g dry weight), evidencing strong environmental and management controls on plaque formation.

Results:

Key results show that warming caused a significant increase in root Fe plaque formation under unamended and normal flooding conditions, with root Fe content rising from 7.46 to 19.94 mg/g, confirming the hypothesis that elevated temperatures amplify plaque formation. Conversely, under digestate-amended conditions, warming had a muted effect on root Fe content, indicating that organic amendments mitigate warming-induced Fe plaque formation. Reduced flooding generally increased root Fe content under ambient temperature but interacted complexly with warming and amendments. Taken together, these outcomes support the central hypotheses posed: (i) warming intensifies root Fe plaque formation, potentially accelerating SOC mineralization, (ii) digestate amendments buffer this effect, stabilizing Fe plaque levels, and (iii) flooding regime modulates plaque dynamics and crop performance in nuanced ways.

CONCLUSION:

Ecologically, the enhancement of Fe plaque formation under warming may increase Fe-mediated SOC mineralization, risking greater C losses from paddy soils and elevated greenhouse gas emissions. Yet, the application of organic amendments and managed water regimes can reduce these risks by stabilizing Fe plaques and potentially protecting SOC stocks. This interplay between climate factors, soil chemistry, and agronomic practices underscores the importance of integrated management strategies to sustain rice productivity and soil carbon sequestration in a warming world.

KEYWORDS:

Iron plaque, warming, digestate amendment, paddy soil, SOC stabilization

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GT 04. SOIL BIOLOGY 2

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 04 - 73 - O

GRAPHITE FOR GRAPHENE: DIGGING INTO THE DIVERSITY OF PRIMARY DEGRADING MICROORGANISMS.

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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In recent years, the use of new nanomaterials has increased dramatically, and with it the need to understand their cycling in the environment. Graphene is one of these nanomaterials, of which biodegradability and mobility are still largely unknown [1][2][3]. Graphene is strictly derived from graphite minerals, and usually commercialised in forms such as few layer graphene (FLG) or graphene oxide (GO) [4][5][6]. Given these considerations, we wanted to know whether there are microorganisms that biodegrade and metabolise graphene in nature. We sampled rocks and topsoils in graphite-rich sites of the N-W Italian Alps, and in nearby control sites devoid of graphite, and studied the associated microbial communities of fungi and bacteria. We analysed soils for total C and N, pH, and used X-ray diffraction to estimate the graphite content. We employed metabarcoding analyses (amplification of the bacterial 16S region and fungal ITS2 rRNA), and isolated five fungal strains present only in graphite-rich soils and rocks. We tested their capacity to degrade/metabolize FLG in vitro using Raman spectroscopy. All the soils presented a sandy-loam texture; graphite-rich soils had total C values up to 60% (ca. 5% in neighbouring control sites) and C/N values in the range 35-400 (less than 15 in control sites). X-ray diffraction confirmed the presence of graphite in graphite-rich soils. Both bacterial and fungal communities seem to be strongly driven by graphite content, with the occurrence of taxa related to hydrocarbon pollution while all but one isolated fungi show biodegradation capacity of FLG after 30 days in vitro.

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GT 04 - 99 - O

SOIL MICROHABITATS – HOW DO SOIL MICROORGANISMS BENEFIT FROM THEIR LOCAL ENVIRONMENT?

GT 04. SOIL BIOLOGY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The understanding of the interaction between soil microorganisms and their local environment has been improved in recent years through complex experiments under near-natural conditions. While the rhizosphere and the detritusphere are already very well studied, much less is known about the mineralosphere and hyphosphere. In this talk, different experiments on the colonisation and function of soil microorganisms in these two microhabitats will be presented. As part of the Biodiversity Exploratories project (https://www.biodiversity-exploratories.de/en/), we exposed goethite and illite to soils in grassland and forest ecosystems to study the microbial colonisation of these minerals under different land use intensities (1, 2, 3). In grasslands, fungi colonised the minerals faster and incorporated more 13C from amended labelled substrates into their biomass than bacteria. In forest soils, fungal colonisation of the minerals was driven by taxa-specific preferences for the C- and nutrient-poor microhabitat. By exposing so-called 'hyphoboxes' in a grassland soil, we wanted to test whether fungal hyphae connect different microhabitats and whether the interaction of fungi with bacteria stimulates the nutrient uptake by plants. Within these hyphoboxes, we separated a 13C-15N-labeled substrate, a hyphosphere, and a rhizosphere compartment by using different mesh sizes. The quality of the added substrate (recalcitrant root litter or labile arginine) affected not only the assembly of the hyphosphere microbial community but also N transport to plant roots. In conclusion, these experiments demonstrated how the local environment as well as microbial interactions determine the role of soil microorganisms in C and N cycling.

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GT 04 - 131 - O

DIVERGENT ASSEMBLY: UNRAVELLING SOIL MICROBIAL DYNAMICS ACROSS CLIMATE AND LAND-USE GRADIENTS

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil microbial diversity is crucial to ecosystem functioning, yet it is increasingly threatened by climate change and intensified land use. While microbial groups exhibit distinct environmental preferences, the mechanisms driving their assembly processes remain poorly understood. Here, we analyse microbial assembly processes using 16S, ITS, and 18S amplicon sequencing data from 141 soil samples collected along a ~1300 km transect, covering a precipitation gradient from 229 mm (arid) to 1388 mm (humid) and three land uses (natural, pasture, and cropping). Our findings reveal that bacterial communities are predominantly shaped by deterministic processes, whereas fungi and protist communities are more influenced by stochastic forces, triggering distinct biogeographic patterns among microbial groups. Bacteria respond strongly to soil properties, particularly pH, while fungi respond markedly to land-use changes. Protists exhibit the least variation in response to environmental factors. Climatic gradients significantly affect microbial assembly, with bacteria showing distinct patterns compared to fungi and protists across the arid-to-humid climate. Land use further modulates these assembly processes within climate zones: in humid regions, it enhances variable selection for bacteria and ecological drift for protists, while in semi-arid regions, it promotes homogeneous selection for fungi. Together, our findings advance predictive models of soil microbial responses to anthropogenic pressures under climate change.

GT 04 - 179 - O

INFLUENCE OF COVER CROPS ON SOIL MESOFAUNA IN AGRICULTURAL SYSTEMS IN PORTUGAL

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Soil degradation has become a critical global concern due to the overexploitation of soils over the past century, leading to declining soil quality and biodiversity. This poses a significant threat for the future, since the consequences of these impacts are reducing their potential to sustain human needs, thus becoming a critical issue at a global level.

In response, several countries started implementing soil conservation strategies, such as crop diversi-fication and the use of cover crops, as these practices are believed to enhance the soil's physical, chemical as well as biological properties, where the mesofauna groups play a fundamental role in the ecosystem's functionalities.

This study, conducted between 2022 and 2024, evaluated the impact of cover crops on soil mesofauna across six agricultural plots, located in the Ribatejo, Oeste, and Alentejo regions of Portugal. These plots were managed with cover crops preceding the main crops (tomato, maize, and babyleaf vegeta-bles). Samplings were performed during both the cover crop and main crop phases, with untreated plots serving as controls.

The QBS-ar methodology was employed for data analysis, involving in-situ soil sampling, extraction of mesofauna specimens, and respective classification based on their morphological adaptation to the edaphic environment. Results indicated that cover crops signif-icantly enhanced soil mesofauna popu-lations ($p = 0.002$). No significant differences were observed across regions or among the main crop types.



GT 04 - 237 - O

HERBIVORY EFFECT ON SOIL FUNGI COMMUNITY: FROM ROOTS TO PLANT COMPETITION.

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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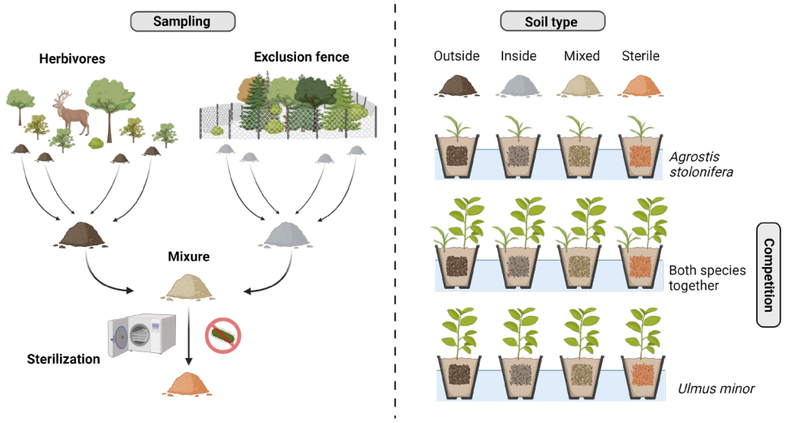
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The influence of herbivores on soil physicochemical properties has been extensively studied; however, their effects on soil and root-associated fungal communities—and the subsequent impact on plant interactions—remain less understood. This study investigates the indirect effects of herbivores on competitive dynamics between grasses and juvenile woody plants through changes in root fungal community composition. A greenhouse experiment was conducted using a common grass, Agrostis stolonifera, and tree seedlings of Ulmus minor. Individuals of both species were grown in pots under three conditions: A. stolonifera alone, U. minor alone, and both species together. Each 1 kg pot was filled with sterilized siliceous sand mixed with 100 g of soil from one of four treatments: (1) soil from within 14-year-old herbivore exclusion areas, (2) soil from outside exclusion areas, (3) a mix of soils from both areas, and (4) a sterilized soil mix. Fungal diversity in the original soils and the roots of three plants per treatment was analyzed via DNA sequencing. Tree seedlings of U. minor grew significantly better without A. stolonifera and in soil from outside the exclusion areas, whereas A. stolonifera was unaffected by the presence of U. minor and grew best in sterilized soil. Plants of Agrostis and Ulmus grown in sterilized soils exhibited minimal arbuscular mycorrhizal colonization and reduced root fungal diversity. Fungal communities in natural soils were similar regardless of herbivore exclusion; however, the fungal community of the roots of experimental plants differed depending on the origin of the soil (treatments) in which they grew. Notably, the presence of A. stolonifera increased fungal diversity in U. minor roots compared to U. minor growing alone. The competitive interaction with A. stolonifera reduced the benefits provided by fungal communities from outside the exclusion areas for U. minor, highlighting the complex interplay between herbivory, fungal dynamics, and plant competition.

ACKNOWLEDGEMENTS

Thank you to Jennifer Krumins for her support during fieldwork. This project was funded by the Spanish Ministry of Science, Innovation, and Universities through the INCREMENTO (RTI2018-094202-A-C22) and MULTI-SPECTRAL EU/Next generation (TED2021-129923B-I00) projects. MC was supported by the Juan de la Cierva Formación 2021 postdoctoral fellowship (FJC2021-046888-I) funded by the Ministry of Science and Innovation and the European Social Fund (NextGenerationEU/PRTR). JB was supported by the FPI/055/2021 doctoral fellowship through the Directorate General of University Policy and Research (Government of the Balearic Islands) and the European Social Fund.



GT 04 - 289 - O

SOIL MICROBIAL COMMUNITIES AS DRIVERS OF HEALTH AND RESILIENCE IN MEDITERRANEAN DRYLAND AGRICULTURE

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Agriculture in Mediterranean ecosystems faces significant challenges. One of the most relevant includes soil degradation; due to soil is a non-renewable resource on human timescales. As a vital component of the soil ecosystem, the soil microbiome plays an essential role in maintaining fertility and is used as a key ecological indicator of soil health.

Comparing biological indices of soil quality such as the dynamics and diversity of microorganisms in sensitive ecosystems like drylands under different agricultural, forestry, and grazing practices, could support decision-making and the selection of sustainable management practices to improve soil quality and resilience to climate change [1].

The proposed study involves 460 sampling paired sites –two nearby locations with different land uses– across Spain, Croatia, Turkey, Greece, Tunisia, Morocco, France, Algeria, and Italy, collecting topsoil samples (0-20 cm). The goal is to obtain microbial indicators and study the microbial population dynamic by using i)DNA-based massive sequencing, ii)phospholipid characterization (PLFA) for taxonomic identification, and iii)enzymatic activity assays to assess functional groups. Initial analyses have been conducted on a subset of samples (mainly woodlands, and olive tree plantations; in Andalusia, south of Spain), focusing on enzymatic activities. The results showed higher activities of β-glucosidase, acid phosphatase, and L-leucine aminopeptidase in woodland soils, probably linked to a more diverse and active microbial community, less impacted by pesticide application compared to the olive tree farm. Conversely, we obtained lower arylsulfatase activity in woodland soils, that may be influenced by specific soil properties, such as the presence of rocks, which could affect sulfur cycling and enzyme function [2]. This integrated approach will provide valuable insights into soil health across the Mediterranean basin.

ACKNOWLEDGEMENTS

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GT 04 - 302 - O

QUANTIFICATION OF FIELD EARTHWORM BURROWING RATES USING REGULAR X-RAY SCANNING DURING A GROWING SEASON

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Earthworms are important soil ecosystem engineers that contribute to soil processes and ecosystem services. Through bioturbation, earthworms alter soil structure by mixing soil particles and creating new pore space in the soil. Nevertheless, quantitative knowledge of in-situ earthworm bioturbation volumes is limited.

The aim of this study was to test a method for quantification of in-situ earthworm burrowing rates from X-ray images obtained from scanning soil columns at regular intervals. We installed soil columns on a grassland site in Uppsala, Sweden, and tested two methodological aspects (re-installation of soil columns after each scan versus use of newly repacked soil columns after each scan). To assess effects of soil moisture on burrowing rates, a wet (natural conditions) and a dry treatment (using rainfall shelters) were employed. We designed and 3D-printed perforated cylinders that allowed earthworms to move in and out of the soil cores. In total, 32 soil columns (eight replicates per treatment; four treatments: two methods x two moisture conditions) were installed in the field in May 2023. The soil columns were removed from the field, X-ray scanned and put back three times during the growing season between May and October 2023. From the X-ray images, the earthworm burrow network was extracted and the burrow volume and the distribution of burrow diameters were determined and differences between scans calculated. We distinguished burrows created by anecic earthworms (burrow diameters >4mm) and by endogeic earthworms. Soil moisture and soil temperature were continuously monitored over the course of the whole experiment using soil moisture probes.

The mean burrowing rates varied between 0.05 cm-3d-1 to 0.64 cm-3d-1 depending on treatment and time of the scanning. Based on these mean burrowing rates, the time to burrow through the entire volume of the topsoil would take approximately 11 to 26 years. Burrowing rates significantly increased with soil water content, while soil temperature did not appear to drive the burrowing rates. The intact soil columns showed the development of burrow volume over time, and revealed information on both created and collapsed burrows, while in the repacked columns it was easier to quantify created burrows but no information on burrow “turnover” is obtained. It was estimated that on average, 58% of the burrow volume was created by endogeic earthworms and 42% by anecic earthworms.

We conclude that the proposed method consisting of repeated X-ray scanning of soil columns in perforated cylinders that allow earthworms to move in and out of soil columns is suitable to quantify and monitor earthworm burrowing rates under field conditions. Intact soil columns are preferred since development (creation and collapse) of the burrow network over time can be studied. Future studies could be carried out with a higher scanning frequency to better understand how soil moisture and soil temperature control earthworm burrowing.







GT 04 - 303 - O

A ONE-YEAR CHRONOSEQUENCE ANALYSIS OF MICROBIAL COMMUNITIES IN AN OLIVE ORCHARD UNDER VARYING MANAGEMENT PRACTICES

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Soil microbial communities in agricultural systems are influenced by a wide range of factors, including soil type, crop type, moisture levels or climatic conditions. Among these, seasonality is particularly significant and must be carefully considered when designing sampling strategies. Land use changes further impact microbial assemblages, making it essential to account for multiple interacting variables when studying microbiome dynamics. A comprehensive understanding of these factors is vital for identifying current and emerging indicators of soil health.

To contribute to this understanding, we collected soil samples from an olive orchard located in southern Spain (Benacazón, Seville) over the course of one year. The orchard, situated on a sloped field (11% gradient), consist of longitudinal plots (8 x 60 m) where the tree rows are treated with herbicide (TL-Herb) and the inter-row spaces are either conventional tilled (CT) or left with a natural cover mixture (MC). The objective of the study is to assess seasonal variations in soil organic matter and microbial abundance across the slope under three distinct management practices. Phospholipid fatty acid (PLFA), 16S rRNA gene sequencing and enzymatic activity analyses (carbon-related activities: BG, CB, XYL, AG, PHOS; nitrogen-related activities: NAG, LAP) were performed to explore the relationships between microbial composition, functional activity, and organic matter dynamics along the slope.

We observed seasonal fluctuations in microbial biomass, with reduced abundance during warmer periods. We detected higher microbial diversity, biomass, and enzymatic activity in MC plots, while stress indicators derived from PLFA peaked under CT and TL treatments. Furthermore, we observed spatial variation along the slope, with greater microbial biomass in lower sections due to water and nutrient accumulation. These findings enhance our understanding of how microbial indicators can inform soil health assessment across different management regimes.

KEYWORDS:

microbial profiling, soil management, sustainable agriculture, soil health indicators



GT 04 - 325 - O

DUNG BEETLES DOESN'T PLAY DIRTY

GT 04. SOIL BIOLOGY / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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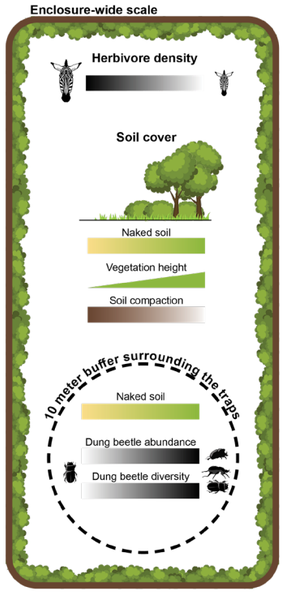
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Surfaces dedicated to grazing activity decrease worldwide, while the biomass of livestock increases, resulting in high density of herbivores in enclosed pastures. It has direct impacts on the biodiversity and on the physical and chemical properties of the soil, mostly because of grazing and trampling, and leads to a decrease in vegetation height and diversity, an increase of soil compaction, and an increase of accidental mortality of soil fauna. Dung beetles provide important ecosystemic services to animal production. In this study we investigated the grazing effect on the dung beetle community in enclosures creating a gradient of herbivore density, where herbivores were fed the same diet. We hypothesized that higher density of herbivores induces an increase of resource quantity, and a decrease of the vegetation cover and height. We also hypothesized that paracoprids would be less represented in dung beetle communities living in high density of herbivores. Dung beetle community was assessed using 66 non-lethal traps during spring 2023 and 2024. We characterized the vegetation cover and the soil compaction at the enclosure scale, and we characterized the vegetation cover, the feces abundance and the habitat diversity in a 10 meter buffer surrounding the traps. We captured 830 dung beetles, belonging to 12 species. Both Onthophagus vacca (n= 269) and Onthophagus ruficapillus (n= 223) represented more than half of the abundance. Our results show that the surface of naked soil increased in high herbivore density enclosures, and the vegetation height decreased. We observed that the surface of naked soil at the trap scale has a significant negative effect on abundance and diversity of dung beetles. Despite that they are resource dependent, we demonstrated that at high densities of herbivores, the dung beetles were mostly impacted by the mechanical pressures applied on the soil caused by both trampling and agricultural engines.

ACKNOWLEDGEMENTS

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GT 04 - 328 - O

EXPLORING SOIL BIODIVERSITY PATTERNS THROUGH A MULTI-TAXA AND MULTI-ENVIRONMENTAL LENS

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Understanding how global change drivers affect biodiversity is an urgent challenge for conservation science. While aboveground biodiversity has received considerable attention, soils remain largely understudied - partly due to the technical difficulty of accessing and characterizing their biological communities. However, recent advances in genetic tools are opening a new window into the hidden life belowground.

In this study, we used DNA metabarcoding - a technique that allows for the parallel identification of multiple organisms through genetic markers - to assess the diversity of bacteria, fungi, nematodes and microarthropods across more than 100 sites in north-eastern Iberian Peninsula. These sites span a range of habitats and climates representative of major environmental gradients across Europe, providing a broad environmental context to investigate how soil biodiversity is structured across taxa and space. By combining community-level data with detailed information on soil properties, vegetation and habitat structure, anthropogenic influence, and climate, we examined the factors shaping community richness and diversity.

Our findings reveal consistent cross-taxon patterns and strong associations with environmental variables, suggesting that soil biodiversity is not shaped by isolated drivers, but by a complex web of interacting soil conditions that vary across spatial scales. While we developed highly explanatory models for most groups, a striking finding is the role of soluble manganese, which showed consistent and generalized effects on most biological groups studied. This raises intriguing questions about its role in shaping microhabitats by imposing potential metabolic constraints .

Our multi-taxa, multi-environmental driver approach helps fill critical knowledge gaps in soil ecology and aligns with Europe's growing policy and research emphasis on belowground biodiversity as essential to ecosystem health and resilience. There is a need to extend this type of standardized, integrative research across Europe's natural habitats - as it enables capturing ecological diversity at scale.

ACKNOWLEDGEMENTS

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GT 04 - 359 - O

SOIL ENZYME ACTIVITY MONITORING THROUGHOUT THE YEAR IN OLIVE ORCHARDS WITH COVER CROPS.

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Traditional tillage is the management practice used in 67% of the olive groves in the Community of Madrid (central Spain) to prevent competition for water and nutrients with the surrounding vegetation. The use of alternative management practices, such as cover crops instead of traditional tillage, provides profits to the ecosystem services delivered by olive groves. These benefits include erosion prevention, soil structure improvement through increased soil organic matter content, enhanced carbon sequestration, greater biodiversity, and support for soil microbial activity, among others. Soil biological properties are sensitive to management practices and are often the first to show signs of change. As such, they serve as early indicators of the impact that different agricultural strategies have on soil health and ecosystem functioning. The aim of this work is to evaluate how soil management, with different types of cover crops, influences soil enzymatic activity at different moments throughout the year. A trial was performed in an intensive olive orchard of 238 trees·ha-1 on the Experimental Farm “La Chimenea” (IMIDRA), southern Madrid. There were four different soil managements: i) traditional tillage, ii) permanent grass cover (Brachypodium distachyon (L) P. Beauv.), iii) permanent spontaneous vegetation and iv) annual legume cover (Vicia ervilia (L.) Willd). Soil sampling was carried out at two depths (0-5 cm and 5-10 cm), once throughout the different seasons between spring to winter 2025. The samples taken were kept refrigerated and then sieved at < 2 mm, before the analysis. In each soil sample, α-glucosidase, β-glucosidase, β-galactosidase, arylsulfatase, N-Acetil-glucosaminidase and phosphatase activities were determined following ISO 20130 standard. An analysis of variance was performed with a general linear model (IBM SPSS Statistics). Preliminary results indicate higher enzymatic activity for β-glucosidase and phosphatase across all management practices and seasons analysed, however, in autumn, an increase in α-glucosidase content is also observed. Tillage showed the lowest enzymatic activity compared to vegetation cover management across all studied moments. Summer had the lowest enzymatic activity due to the effect of summer drought. Nevertheless, the greatest differences between treatments for the majority of the enzymatic activities occur in autumn, with an increase in permanent vegetation cover of Brachypodium and spontaneous vegetation by 55% and 107%, respectively, compared to tillage. This could be explained by the effect of soil tillage before autumn soil sampling and to the increase of ground water from the first rains improving soil with vegetation cover conditions.

ACKNOWLEDGEMENTS

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GT 04 - 361 - O

AN INTEGRATED SOIL OMICS AND MACHINE LEARNING APPROACH TO PREDICT MULTIFUNCTIONALITY IN AGRICULTURAL SYSTEMS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Introduction:

The intensification of agricultural practices, marked by increased chemical inputs and intensive tillage, negatively impacts soil biodiversity and alters essential soil functions. While sustainable agricultural practices are gaining traction, their short-term effects remain challenging to quantify using conventional physicochemical indicators. This innovative study explores soil microbiome analysis and machine learning to identify biological indicators sensitive to different cropping systems and to develop predictive models of soil health in agricultural systems.

Materials and methods:

Our research mobilized a large dataset of over 3,000 soil samples from 426 sites across Eastern Canada. We characterized the soil microbiome and integrated it into machine learning models, considering soil properties and climatic factors. Various omics data pre-treatment strategies, including centered log-ratio transformation, kingdom balance, taxonomic and functional approaches, were compared to optimize prokaryotic, fungal, and microeukaryotic data integration. We evaluated the performance of five learning algorithms (including ensemble models and SVM) to predict soil profile carbon stock, soil aggregation, and macroporosity.

Results:

Our methodological approach, leveraging omic aggregation as a hyperparameter for data clustering, yielded high-performance models ($R^2 > 0.7$) for predicting soil profile carbon stocks, macroporosity, and soil aggregation. The centered log-ratio and kingdom balance methods outperformed other pre-treatment strategies despite generating more variables. Shapley value analysis revealed significant relationships, highlighting the distinct contributions of the three microbial groups within our models.

Conclusions:

Integrating omic signatures enhances the prediction of soil health and provides a more sensitive and integrated approach than relying solely on physicochemical factors. These microbial signatures constitute valuable tools for constructing knowledge graphs and developing decision-support systems, thereby contributing to the advancement of sustainable agricultural practices.



GT 04 - 374 - O

DEEP SOIL MICROBIOTA AND THEIR FUNCTIONING: HIDDEN PARTNERS FOR AGROFORESTRY IN THE TROPICS?

GT 04. SOIL BIOLOGY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Soils host 59% of terrestrial biodiversity, and their microbiota plays key roles in carbon cycling and for plant growth, water uptake and survival. However, our knowledge of soil microbiota and functions rely mostly on surface horizons, while plant roots as well as mycelium can explore deeper soil layers, and interact with a diversity of physico-chemical context. In tropical area, such as soils of the Berambadi watershed, deep roots have been observed up to 10 meters below the surface, especially in agroforestry sites. We therefore explored the microbiota along the soil profile interacting with tree roots, testing how far microbial diversity and functions vary in depth in agroforestry sites, as well as in more conventional agriculture.

The microbiota was described by sequencing 16S and ITS1 barcode for bacteria and fungi respectively on 79 samples collected along the soil profile of two installed pit, at 100 meters distance, one for each site. Both rhizospheric and bulk soils were collected, and soil physico-chemistry was measured for each sample. The comparison with Genbank, Silva and Fungal Traits database allowed to describe the taxonomic and functional diversity.

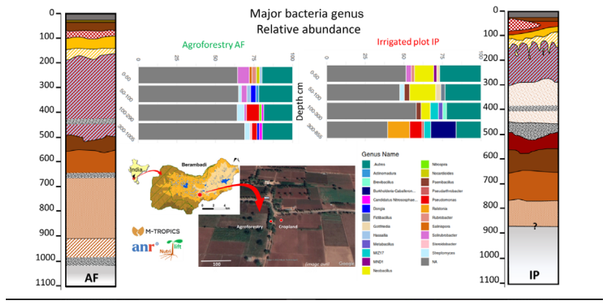
Fungi and bacteria showed contrasted patterns along the soil profile. Bacteria diversity was richer in the rhizospheric soil, and its diversity clearly decreased with increasing depth. Deeper soil bacteria were for example 30 times more abundant in rhizosphere than in the surrounding soil at 10 m depth. On the other hand, fungi diversity was not significantly different among soil types, decreased at the beginning of soil profile but increased remarquably at 10 m depth. Differences of functional diversity was rather observed between the two sites and cultivation practice, with deep soils in agroforestry hosting bacteria belonging to Pseudomonas and Nitrospira genera – possibly involved in the nitrogen cycle while irrigated soil showed bacteria from distinct genera such as Burkholderia.

Moreover, microbiota changed in terms of composition all along the soil profile, for both bacteria and fungi, associated in particular with groundwater table fluctuation zone. Finally, changes of community composition with depth were greater in irrigated site compared to agroforestry one, suggesting a possible homogeneization linked with tree root diversity and their exploration and well as interaction with the soil profile.

This pioneer study reveals the major differences between soil microbiota in surface and interacting with deep tree roots, highlight their importance to understand cultivation practices impact on water circulation and soil carbon cycling. We also detected a large part of unknown diversity using metabarcoding of soil eDNA, inviting to future studies to precise the diversity and functions of deep soil microbiota in the tropics.

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GT 04 - 399 - O

AGRICULTURAL LAND USE REDUCES SOIL BIODIVERSITY: INSIGHTS FROM A GLOBAL META-ANALYSIS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Agricultural land use is a leading driver of soil biodiversity loss and a major, yet often overlooked, threat to global ecosystem resilience. In this study, we present a comprehensive global meta-analysis of soil faunal responses to agricultural land use, synthesizing data from 110 studies across 130 locations in 35 countries. By benchmarking agricultural systems against undisturbed reference ecosystems, we assess the effects of various agricultural land-uses on key soil faunal groups: nematodes, springtails, mites, and enchytraeids.

Our analysis reveals a consistent decline in the taxonomic richness of nematodes, springtails, and mites under agricultural land use. The strongest negative effects were observed in arable croplands and monocultures, while more diversified systems such as polycultures and agroforestry showed comparatively moderate impacts. Springtails and mites exhibited particularly high sensitivity across a wide range of climatic zones, suggesting that mesofauna may be especially vulnerable.

We found that the impacts of agriculture are not uniform but strongly modulated by environmental conditions. In regions with higher mean annual precipitation, the negative effects on faunal density and richness were significantly amplified—likely due to increased leaching of agrochemicals and habitat disruption. Soil properties also played a pivotal role: higher pH and greater organic matter content were associated with steeper declines in richness, particularly for mites and springtails. Soil compaction, reflected in increased bulk density, further exacerbated biodiversity loss, especially in clay-rich soils.

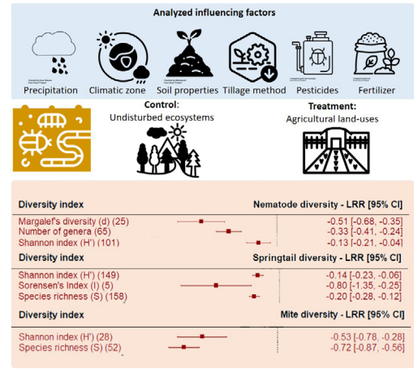
Management practices had variable effects. Combined mineral-organic fertilization and pesticide use significantly reduced nematode density, while organic fertilization alone tended to support nematode richness. Tillage practices did not show consistent effects on faunal densities, indicating that broader land-use regimes (e.g., cropping systems, rotations) may be more influential than single interventions.

Despite clear overall trends, effect sizes varied substantially, highlighting the risks of generalized land management prescriptions. Our findings underscore the need for biodiversity-sensitive land use that promotes diversified agroecological systems, long-term soil biodiversity monitoring, reduced compaction and chemical inputs, precision technologies, and farmer education through participatory approaches.

Preserving soil biodiversity is critical not only for ecosystem function and productivity but also for the long-term sustainability of food systems. This meta-analysis provides the empirical foundation to inform policy and practice toward that goal.

ACKNOWLEDGEMENTS

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Graphical abstract - Effects of agricultural land use on the diversity of selected soil fauna



GT 04 - 427 - O

AN INTEGRATED APPROACH TO DEFINE THE SOIL ARTHROPOD COMMUNITY RESPONSE IN AGRIVOLTAIC SYSTEMS

GT 04. SOIL BIOLOGY / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The increasing adoption of AgroPhotoVoltaic (APV) systems, which combine solar panels with agricultural practices, has the potential to address the competing demands for land between food production and renewable energy. While research on the impact of APV systems on crops and the environment has advanced, the effects on soil biodiversity, especially soil arthropods, remain insufficiently studied. Soil arthropods are crucial indicators of soil health, playing key roles in nutrient cycling, soil structure formation, and pest control. However, their responses to APV, in relation to microclimatic and soil property changes induced by solar panels, are not well understood.

This study, part of the PNRR SUNRISE project – n. P2022ALZMM, aimed to investigate the effects of APV on soil biodiversity, focusing on soil arthropods metrics. This study, conducted at an APV site located in northern Italy and operated by REM Tec, investigates the effects of agrivoltaic trackers (type: Agrovoltaico 3D bi-axial tracker) with varying Ground Coverage Ratios (GCR—the proportion of ground shaded by panel arrays) on the diversity of the soil arthropod community. Field experiments were conducted in two crop-cultivated fields (tomato and durum wheat) using two configurations: standard (STV1, GCR = 13%) and extended (STV2, GCR = 41%, only for wheat) trackers, compared to control plots under full sun and grass cover. Soil samples were collected over multiple growing seasons to assess key indicators of microbial activity, including soil pH, organic matter content, and soil respiration as well as the soil arthropod metrics.

The study showed that soil biological quality and respiration patterns were notably distinct under grass and tomato treatments. Kendall's correlations indicated positive associations between Soil Biological Quality index (QBS-ar, based on arthropods) and CO_2 emissions, organic matter content (SOM), and temperature, while showing negative correlations with pH. Differences in soil chemical parameters were more evident in tomato than in wheat, especially under sun exposure and shading treatments. Soil respiration was higher in warmer seasons and consistently elevated in grass-covered soils, while shading alleviated respiration in extreme temperatures. Arthropod abundance and diversity (number of orders, QBS-ar) varied with crop phenology and the type of treatment, with control plots typically supporting higher diversity. These findings emphasize the significant role of temporal and management-driven changes in shaping soil biotic and abiotic interactions, reinforcing the importance of integrative indices for monitoring agroecosystem health.

GT 04 - 492 - O

SOIL BIOTA COMMUNITIES AND KEY SOIL ECOSYSTEM FUNCTIONING PROCESSES ACROSS A MEDITERRANEAN CLIMATIC GRADIENT

GT 04. SOIL BIOLOGY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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There is a need for taking into account holistic approaches in the study of the relationships (interactions) between soil fauna (macro-, meso- and micro-) and soil microorganisms (bacteria and fungi) and the soil environmental factors. Soil microbiota thrive and influence important functions like soil organic matter (SOM) dynamics, while large bioturbation activities performed by soil invertebrates also influence important functions like aggregation, and hence SOM dynamics, and water infiltration.

Soil biodiversity communities, i.e., microbiota, nematodes, and earthworms were characterized in different ecosystems (natural versus agroecosystem) along a climatic gradient from the Ebro valley's semi-arid lands to the Pyrenees subalpine areas. Soil samples were taken and soil biodiversity was characterised by its taxonomic, genotypic (DNA barcoding) and functional dimensions. Data on abundance, biomass and functional groups of each taxon were obtained. Basic soil characteristics were analysed like pH, CEC, texture, organic C, inorganic C, P, bulk density, water aggregate stability, aggregate distribution. Other more specific analyses were: water infiltration, soil C fractionation, N mineralization in the lab, and coarse and fine root length and biomass. Our objective was to link soil biota with relevant soil environmental factors affecting their distribution and also to explore the linkages among these soil taxa with the use of multivariate analyses.

Our results showed that community structure varied across the gradient. Specifically, earthworm communities ranged from only one species present in the semiarid lands, with quite specific life habits, to 4-5 species in the Prepyrenean and subalpine sites. Nematode abundances and trophic groups responded to both altitude and management gradients. Herbivore nematodes decreased with increasing altitude, being highly abundant in agricultural soils in semi-arid lowlands. Bacterivore nematode, especially enrichment-opportunistic, were enhanced in agricultural soils too. Oppositely, omnivores and predators, greatly sensitive to environmental disturbance, were greatly reduced in agricultural compared to natural soils, and nematode-based soil food webs were progressively more complex with reduced perturbation and increased altitude. Soil microbial biomass was lower in the semiarid lands compared to Prepyrenean and subalpine sites. The richness of soil microbiota decreased in the altitudinal gradient, from semi-arid lands, where we observed the highest richness to subalpine and Prepyrenean areas. Moreover, no influence of soil depth was observed.

In this presentation we provide the first study on assessing the indirect interactions between earthworms, microbiota and nematodes along a climatic gradient and soil environmental factors in the region, contributing to unveil one of the priorities in soil ecology research.

ACKNOWLEDGEMENTS

Financial support was provided by the project PGC2018-094332-B-I00 (MEC).





GT 04 - 512 - O

CITIZEN-BASED IDENTIFICATION OF EARTHWORM MORPHOTYPES: INSIGHTS FROM A LARGE-SCALE BIODIVERSITY MONITORING NETWORK IN FRANCE

GT 04. SOIL BIOLOGY / GT 16. CONNECTING PEOPLE AND SOILS

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Monitoring soil biodiversity remains difficult, particularly due to the high spatial and temporal resolution required to accurately reflect the dynamics of soil communities in cultivated landscapes. Earthworms, as key soil organisms, are commonly used as indicators, but their identification in the field is constrained by the difficulty of assigning individuals to species without expert knowledge. As a result, classification into morphotypes is often used as a practical alternative. This study examines the reliability of such classification within the French '500 ENI' (Non-Intended Effects) Monitoring Network, which involves annual sampling in agricultural plots, followed by expert verification of identifications. Using data from over 48,000 earthworms collected across more than 950 plots, we calculated two indicators to assess classification reliability: the misclassification rate (MR) and the undetected rate (UR). Results showed an average MR of 28% and an average UR of 32%, with substantial variation depending on morphotype. Endogeic individuals were classified more reliably than epigeic types and anecics (both red- and black-headed). The reliability of classification was strongly influenced by the sampler's experience as well as by community characteristics, particularly total abundance, proportion of adults, and morphotype diversity. Our findings emphasize the need for strengthened support for participants with limited experience. In particular, we recommend developing targeted training materials and decision aids to improve classification accuracy. Specific attention should be given to plots with low-density communities, few adults, or low morphotype diversity, where classification is most error-prone. Additionally, promoting sampling during periods with favorable conditions for earthworm activity and maturity could help improve both detection and reliability. These measures would contribute to increasing the robustness of large-scale biodiversity monitoring efforts relying on morphotype-based assessments.

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GT 04 - 538 - O

CROSS-HABITAT MICROBIAL INTERCONNECTEDNESS IN ALPINE GRASSLAND ECOSYSTEMS

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The diversity of soil microorganisms is notoriously difficult to explain, given the complexity and dynamic nature of soil ecosystems. However, traditional perspectives examine soil microbial diversity separately from microbiota within or associated with higher organisms that inhabit the soil. Here, we seek to challenge such view and propose an alternative and holistic interpretative framework in which the soil meta-community is the combined set of different microbial communities belonging not only to the soil itself but also to the various organisms living in or interacting with it.

Applying a cross-habitat perspective within a grassland ecosystem, this study explores soil prokaryote and fungal diversity and associated microbiota in mammals, invertebrates, and plants in alpine pastures. The study comprises more than 900 samples of soil, rhizosphere (Carex spp. and Festuca spp.), invertebrates (nematodes, collembolans, earthworms, and beetles), and vertebrates (feces of hares, wild ungulates, and livestock) collected along an elevational gradient at the Long-Term Socio-Ecological Research (LTSER) site Matsch/Mazia (Italy), a model site for studying the effects of climate change and land use in the European Alps.

We found that, in addition to climatic and soil properties, microbiota from other living organisms in the grassland ecosystem significantly contribute to the soil microbiome and are, in turn, influenced by it, with surprisingly close connections between soil and higher animals. Fungal and bacterial taxa revealed greater overlap between soil, rhizosphere, and soil-dwelling invertebrates, compared to other invertebrates and vertebrates, although a core microbiota was present across all organisms.

Our data underscore the connectivity of soil with other ecosystem compartments, even across a 1500 m elevation gradient, and demonstrate the above/belowground and host/habitat-specific associations in the alpine meta-community.



GT 04 - 648 - O

SOIL FORMATION FROM DREDGED SEDIMENT: EVOLUTION OF BIOCHEMICAL AND PHYSICAL PROPERTIES

GT 04. SOIL BIOLOGY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Using dredged material from ports and waterways in agriculture, forestry, and construction (e.g., dike building, habitat restoration) is gaining interest. For such applications, organic matter (OM) must be stable, which can be achieved through soil ripening—a process that transforms waterlogged, anoxic sediment into aerated, soil-like material via drainage and oxidation.

This study examines the ripening of mechanically dewatered dredged sediment from the Elbe River around the port of Hamburg, deposited into nine stockpiles (1,000–2,200 m³) managed under different turning frequencies (none, 2×/year, 4×/year) and vegetation management (removed before turning or not). OM stability and microbial activity were assessed over two years using soil respiration, the Tea Bag Index (TBI), and Rock-Eval pyrolysis (RE7S). Proctor compaction tests were performed to ascertain the compactibility of the soil, and shrink-swell behavior was assessed using the Coefficient of Linear Extensibility (COLE). Samples from several decades' old locations ('historical sediment'), where dredged sediment had been applied for soil amendment, served to benchmark ripened material.

Carbon release and decomposition rates (k) decreased over time (Fig. 1, left), whereas the stabilization factor (S) increased. These trends reflect the depletion of labile OM and a shift toward recalcitrant ones. Respiration in the top layers of stockpiled sediment was higher than in lower layers, reflecting enhanced exposition to atmospheric air, enabling advanced stages of soil ripening. Rock-Eval pyrolysis detected a relative increase in recalcitrant carbon and the Oxygen Index (OI), while the Hydrogen Index (HI), reflecting labile OM, decreased (Fig. 1, middle).

Also, the soil physical parameters indicated significant changes in the material over the course of ripening. Proctor density (Fig. 1, right) increased by 13.64% in the control stockpile (SP4) from 1.10 g/cm³ in the initial material (HIP) to 1.25 g/cm³, and higher turning frequencies of the stockpiles led to higher compactibility. COLE values significantly decreased in all stockpiles to values below 0.14 at the latter part of the monitoring period, indicating progressively decreasing shrink–swell behavior.

These findings reveal how the combined biological breakdown of organic matter (OM) and mechanical processing enhances the structural and functional properties of dredged sediment for use as an earthen construction material.

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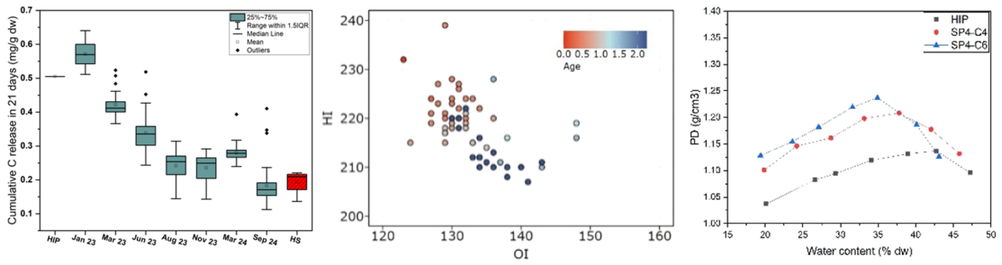
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Respiration (left), HI and OI indices (middle) and Proctor curves (right) over time of soil ripening.

GT 04 - 698 - O

HOW USEFUL ARE SOIL BIOTA AS INDICATORS OF SOIL HEALTH: UNDERSTANDING THE IMPACTS OF MANAGEMENT PRACTICES ON SOIL BIOTA AND ASSOCIATED SOIL FUNCTIONS.

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Monitoring soil health is often well intentioned, but monitoring systems are often defined with simplicity in mind and avoid the measurement of soil biota, which are construed as difficult and expensive to quantify. But ignoring soil biota in soil monitoring systems, comes at what cost? Soil biota are essential to soil health, and are often considered the backbone or drivers of many soil functions. It is also well-known that agricultural management practices can have a significant effect on soil biota and the functions that they support. However, to date the assessment of the impacts of management practices has been focused on either single sites or few biological taxa.

Over the last two years, the EU BENCHMARKS project has systematically evaluated the role of soil biota in supporting a range of soil functions through the provision of a series of soil processes. To support the development of a soil health framework, a series of knowledge graphs have been developed that identify the links between soil biota and a range of soil physical and chemical properties and processes that underpin four soil functions. To quantify how soil management practices may disturb or impeded the provision of these processes and soil functions, two approaches have been developed. 1) A through a detailed meta-data analysis of 790 pairwise combinations of management effects, supported by 74526 literature observations and 2) Measurement of soil biota and biologically mediated soil processes across a range of soil management treatments from seven geographically representative Long Term Experimental sites in Europe.

This presentation will introduce the knowledge graphs developed and how soil management practices affect a wide range of soil biological actors, including macrofauna, mesofauna, microfauna, and the microbiome. Additionally we will define the consequences of these management impacts on the associated processes which are mediated by different biological actors, such as infiltration or structure formation led by macrofauna activity compared to microfauna related nutrient and carbon cycling processes. Through this assessment of impacts of management practices on soil biota and their associated soil processes, we can define strong candidates for biological indicators of soil health as a result of soil management.



GT 04 - 745 - O

TOWARD SCALABLE BIOCRUST RESTORATION: THE SUCCESSFUL RECIPE FOR CYANOBACTERIAL INOCULUM COLONIZATION

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Biological soil crusts, also known as biocrusts, are complex communities of microorganisms intimately associated with the uppermost soil layer. This living soil covers play fundamental roles in dryland ecosystem functioning, contributing to soil stabilization, enhancing water retention, and significantly supporting nutrient cycling. In recent years, the use of biocrust has gained recognition as a viable technique for ecological restoration. This approach holds promise both for the recovery of damaged biocrust communities affected by anthropogenic disturbances and for the broader rehabilitation of arid and semiarid ecosystems. Among the biocrust-forming organisms, cyanobacteria stand out for their potential in restoration efforts, particularly due to their resilience in harsh environmental conditions and their capacity to improve soil fertility, structure, and resilience, thereby improving the microenvironment for late-successional microorganisms. Despite their potential, large-scale application of cyanobacterial inoculum is frequently constrained by production inefficiencies, limited shelf life, transportation challenges, and variable success in field establishment.

This study explores pelletization as a novel approach to support large-scale delivery and performance of cyanobacterial inoculum. Cyanobacteria were incorporated into pellets formulated with different organic amendments (paper residues, biochar, and vermicompost) to assess their impact on physical integrity, inoculum viability during storage (up to four months), and effectiveness in promoting cyanobacterial establishment in degraded soils.

Pellet composition significantly influenced all these factors. Paper-based amendments (both shredded paper and paper pulp) provided strong structural integrity, resisting disintegration, and created a favourable microenvironment that supported cyanobacterial growth. However, soil colonization by the cyanobacterial inoculum delivered via paper-based pellets was less efficient than expected. Conversely, biochar-vermicompost pellets, though structurally weaker and less effective at preserving cyanobacterial viability during storage, successfully facilitated inoculum transfer and soil colonization. This effectiveness was likely driven by the nutrient-rich composition of vermicompost and the disaggregation properties of biochar, especially at lower amendment concentrations.

These findings emphasize the importance of balancing physical and chemical properties in pellet formulation. Tailoring the composition of organic amendments offers a promising pathway to overcome logistical limitations and enhance the scalability of cyanobacterial-based biocrust restoration in dryland ecosystems.

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GT 04 - 750 - O

IMPACT OF SOIL BIODIVERSITY LOSS AND SOIL COMMUNITY COMPOSITION ON SOIL STRUCTURAL PROCESSES AND ECOSYSTEM MULTIFUNCTIONALITY

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Healthy soils sustain a plethora of functions (i.e., primary productivity, nutrient cycling, water regulation and purification, carbon and climate regulation, habitat for biodiversity, pest control, and pollutant degradation) and thus form the foundation for the delivery of ecosystem services. However, increasing anthropogenic activities, such as intensive agricultural practices, put significant pressure on soils and can lead to degradation and loss of biodiversity. Research to date has shown that larger soil organisms, often referred to as ecosystem engineers, are particularly negatively impacted by intensive management practices such as tillage, resulting in the loss of soil structure. To explore whether and to what extent the gradual loss of biodiversity affects the soil’s capacity to support a range of biophysical processes, we employed a sieve-based approach in a six-month mesocosm experiment to selectively exclude larger soil biota. This allowed us to study their influence on the soil structural processes, among other using in x-ray tomography. Furthermore, we also assessed the direct and indirect effects of biodiversity loss comparing soil biological communities originating from distinct long-term tillage regimes (conventional and minimum tillage) on soil biophysical processes, through changes in the soil macro- and mesofauna and microbiome. This was done using morphological identification and amplicon sequencing of 16S and ITS taxonomic markers, combined with structural equation modeling.

Our results demonstrate that soil biodiversity simplification leads to an overall decrease in multiple soil structural processes and ecosystem functions, including aggregation, pore formation and connectivity, nutrient cycling, and primary productivity. We show that larger biota (i.e., earthworms) are key players in the formation of macropores and macroaggregates. There is a significant interaction between arbuscular mycorrhizal fungi (AMF) biomass and aggregate mean weight diameter. We did not find a difference between the performance of soil communities originating from different tillage regimes in keeping up multifunctionality.

In conclusion, this study emphasizes the critical role of soil biodiversity in sustaining soil structure and multifunctionality in agricultural systems. Preserving the integrity of soil food webs, particularly the contributions of larger biota, is essential for developing resilient and sustainable farming practices.



GT 04 - 755 - O

LEGACY EFFECTS OF EXPERIMENTAL STRESS ON ECTOMYCORRHIZAL FUNGAL COMMUNITIES IN OAK TREES

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Acute Oak Decline (AOD) is devastating thousands of native oaks across the UK and continental Europe, with decades of reduced growth predisposing trees to infection by multiple interacting bacterial species [1]. Although extensive research has documented aboveground AOD symptoms, effects on belowground ectomycorrhizal fungi (EMF) networks that support oak nutrition and stress resilience have received minimal attention. This study examines legacy effects of experimental stress treatments on EMF communities in 40-year-old oak trees two years post-treatment.

Trees were subjected to 18 months of drought (via rain exclusion shelters) or nutrient stress (via ringbarking) alongside controls, followed by combinations of wounding and biological inoculations with AOD-associated bacteria and/or Agrilus biguttatus larvae. Rain exclusion shelters were removed in December 2022, and both rhizosphere soil and mycorrhizal root tips were collected in October 2024 to evaluate post-stress recovery responses of EMF communities using ITS metabarcoding across three experimental blocks.

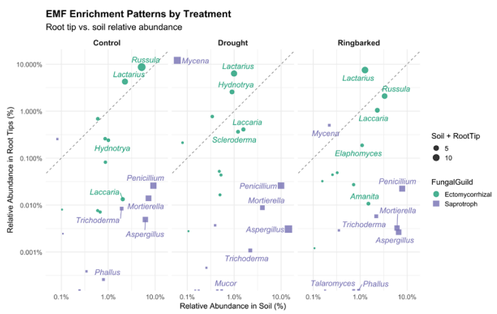
Our analysis revealed striking differences between soil and mycorrhizal communities, with soil harbouring significantly higher diversity across all metrics ($p < 0.001$). Treatment effects persisted two years after stress cessation, significantly affecting fungal community composition in both root tips (PERMANOVA: $R^2 = 9.9\%$, $F = 2.64$, $p < 0.001$) and soil ($R^2 = 5.4\%$, $F = 1.96$, $p < 0.001$). Pairwise comparisons revealed that ringbarking created the most distinct EMF communities, differing significantly from both control and drought treatments in root tips. In soil, drought and ringbarking treatments both differed significantly from controls, but not from each other, suggesting convergent soil community responses to stress.

EMF enrichment analysis identified treatment-specific patterns, with key ectomycorrhizal genera (Lactarius, Russula, Laccaria) showing differential abundance patterns between stressed and control trees. Notably, canonical correspondence analysis demonstrated significant clustering of root tip EMF communities by treatment ($F = 2.91$, $p = 0.013$), while soil EMF communities showed weaker but detectable treatment structuring.

These findings demonstrate that experimental stress treatments create lasting legacies in belowground EMF networks, with implications for oak resilience. The persistence of treatment effects two years post-stress suggests that EMF community recovery may be slower than previously recognized, potentially affecting long-term tree health and AOD susceptibility. This research provides critical baseline data for understanding how belowground networks respond to the types of environmental stressors that predispose oaks to decline.

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Differential enrichment patterns of fungal taxa in root tips versus soil across experimental stress treatments in mature oak trees. Each point represents a fungal genus, with position indicating its relative abundance in soil (x-axis) versus root tips (y-axis) on logarithmic scales. Points above the diagonal line are enriched in root tips relative to soil, suggesting selective colonization or proliferation within root tissues. Green circles represent ectomycorrhizal fungi, while purple squares indicate saprotrophs. Symbol size corresponds to total abundance across both environments. Key ectomycorrhizal genera are labelled to highlight treatment-specific responses. Control trees (left panel) show strong enrichment of Lactarius and Russula, maintaining balanced mycorrhizal communities. Drought-stressed trees (middle panel) exhibit persistent enrichment of Lactarius but altered patterns for other genera, suggesting drought-specific selection pressures on fungal partners. Ringbarked trees (right panel) display distinct enrichment patterns, with maintained Lactarius colonization but altered distributions of secondary colonizers such as Laccaria and Elaphomyces. These treatment-specific patterns reveal how different stress types differentially affect oak trees' ability to selectively associate with beneficial mycorrhizal partners during the post-stress recovery period, potentially influencing their resilience to secondary stressors including Acute Oak Decline.

GT 04 - 782 - O

IMPACT OF DOMESTICATION ON ROOT MICROBIOTA: A COMPARISON BETWEEN CULTIVATED AND WILD VARIETIES BIODIVERSITY

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Understanding how domestication has shaped the rhizosphere microbiota is essential to clarify the ecological consequences of plant breeding and to harness beneficial microbes for sustainable agriculture. Despite increasing interest, the extent and nature of microbial changes induced by domestication remain unclear, partly due to limited comparative data between wild and cultivated plant taxa across different soil environments. To address this gap, we conducted a metabarcoding-based analysis of rhizosphere and bulk soil microbiota from 128 samples collected in agricultural and natural environments in the Trentino region. Domestication and intensive cultivation greatly influence the interaction between plants and their root-associated microbiota (Bulgarelli et al., 2013). However, the effect on rhizosphere microbiota composition and function remains unclear. Studies suggest reduced microbial diversity, but outcomes vary depending on selected plant traits, agronomic practices, and species, and the underlying mechanisms are poorly understood. Our taxonomic analysis revealed genera such as Geomyces and Penicillium, known soil decomposers; Geomyces is particularly associated with cold environments. Mortierella and Solicoccozyma were identified as plant growth-promoting fungi (Carvajal et al., 2024; Ozimek & Hanaka, 2021). Alpha diversity indices showed cultivated plants host significantly richer and more diverse microbial communities, with higher species richness in cultivated roots suggesting a more permissive or selective rhizosphere environment (Tkacz et al., 2015). Beta diversity analysis revealed clear separation between cultivated and wild groups, with cultivated samples forming distinct clusters. These results indicate that domestication shapes not only plant genomes but also root-associated microbial communities, confirming that microbial structure is influenced by domestication, agronomic practices, and soil management (Pérez-Jaramillo et al., 2018).

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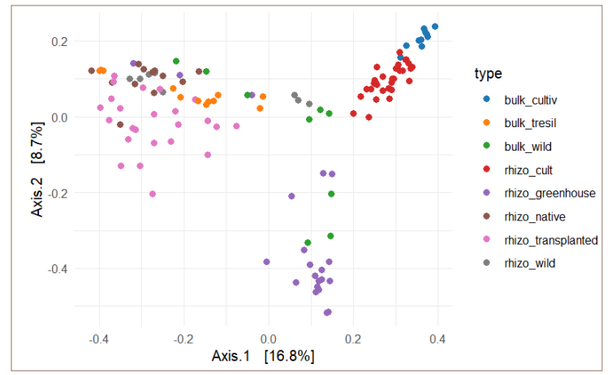
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GT 04 - 788 - O

MOVING BEYOND LAND USE CHANGE: HOW SPECIFIC AGRICULTURAL MANAGEMENT PRACTICES IMPACT SOIL MICROBIAL TAXONOMY AND CARBON CYCLING TRAITS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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To date, soil microbiome research has largely focused on deciphering differences between unmanaged perennial systems and row crop agriculture. While these studies have revealed shifts in microbial taxonomy and function, less is known regarding the capability of specific agriculture management practices to alter microbial structure and function. In 2019, the Soil Health Institute conducted the North American Project to Evaluate Soil Health Measurements. Metagenomic and amplicon sequencing included in the project provided an opportunity to examine how long-term adoption of specific soil health management practices (e.g., cover cropping, decreased tillage, residue retention, etc.), impact microbial taxonomy and function. Results indicate large shifts in bacterial and archaeal taxonomy between no-till and conventionally tilled soils as well as shifts in the abundances of genes related to complex carbohydrate degradation and carbohydrate transport. However, generalized positive trends in carbon cycling traits were not observed along the continuum of conventional row crop management, soil health row crop management, and perennial systems. These results suggest additional innovative soil health management practices in row cropping systems must be implemented to closely mimic root exudates and biomass produced in perennial systems to achieve similar functional capacities.

GT 04 - 779 - O

SOIL MICROBIAL BIOMASS UNDER NO-TILL PRACTICE AND CONVENTIONAL TILLAGE IN A VERTISOL OF CENTRAL MOROCCO

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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In agroecosystems, the soil health is closely linked to the structure, diversity and function of soil microbiomes, as they are sensitive to environmental conditions and cropping practices. The supply of numerous ecosystem services is facilitated by these microbes, which also do regulate a number of crucial activities such as carbon storage, organic matter recycling, and nutrient mineralization. Studies have shown that the conservation agriculture alters the microbial structure and dynamics at the soil surface as well as some of the soil's physical and chemical properties over the course of several years periods. Although agricultural soils in Morocco have undergone significant gains in knowledge, little is still known about the effects of various management practices on the variety of microbial communities. In this context, this study explored the link between the implementation of the no-tillage practice preceded by a subsoiling and changes in the bacterial and fungal biomass under wheat/legumes rotation cropping system in a Moroccan modal Vertisol. 21 soil samples were collected at 0-5cm,5-10cm,10-15cm horizons in a 1ha NT experimental plot located at the Marchouch area. Equivalent samples were also taken from a neighboring 1ha plot under conventional tillage (CT). The composition of soil bacterial and fungal communities was profiled using 16S rRNA and 18S rRNA sequencing technique. Results indicated that NT promotes fungal, bacterial and soil microbial biomass (SMB) compared to CT for the three soil layers. The fungal biomass in soils under NT is significantly higher (104%) compared to CT in 0-5cm and 134% in 5-10 cm. Similarly, an increase in bacterial biomass of +30% was observed in favor of NT soil for both 0-5 and 5-10 cm. Also, SMB is significantly higher in soils under NT than under CT (+77%) in 0-5cm and +95% in 5-10cm. Moreover, the ratio F/B was higher under NT for the three layers. The ratios were 2.77, 2.73 and 1.84 for 0-5, 5-10, and 10-15cm layers while those under CT were 1.76, 1.56 and 1.51. These results confirm that NT favors the dominance of fungi over bacteria during the years of transition to NT. This is explained by the crop residues retention on the soil surface and the high soil moisture in NT.

KEYWORDS

bacterial, fungal, microbial, biomass, no-tillage, conventional tillage, Vertisol, Central Morocco.



GT 04 - 807 - O

DROUGHT-DRIVEN SHIFTS IN WHEAT-ASSOCIATED MICROBIOMES: INSIGHTS FROM SPAIN AND ITALY

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil microorganisms are key to agricultural ecosystem health, influencing crop productivity and resilience to climate change. In the TRIBIOME project, a study focused on microbial communities in the rhizosphere and interior of wheat plants, aiming to assess how environmental factors and farming practices affect their composition and function. During the 2022/2023 growing season, experimental plots were established in Spain and Italy using soft and durum wheat. Geo-referenced soil and plant samples were collected at flowering, maturity, and post-harvest stages for metagenomic analysis via DNA extraction.

A total of 1,052 rhizosphere and bulk soil samples were analysed using 16S rRNA and ITS metabarcoding to explore bacterial and fungal communities under optimal irrigation and high aridity. The study, carried out in fields with Triticum aestivum and T. durum, aimed to understand microbiome dynamics under environmental stress. Significant differences were observed between rhizosphere and bulk soil microbiomes, regardless of wheat species. Microbial α-diversity was higher with irrigation, while arid conditions reduced diversity and altered community structures. Among bacteria, Bradyrhizobium, Paenibacillus, Microvirga, Gemmata, Variovorax, Microbacterium, and Sphingomonas emerged as recurrent genera enriched in both rhizosphere and bulk soil under high aridity. Similarly, among fungi, the genera Talaromyces, Periconia, Mortierella, Curvularia, and Rhizopus were frequently overabundant in arid conditions.

These trends appeared consistent across wheat types, suggesting a non-specific microbial response to aridity. However, soil-specific properties likely mediate these effects and warrant further investigation. Overall, the findings deepen our understanding of microbiome responses under climate stress and support the development of microbiome-based strategies for sustainable agriculture.

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GT 04 - 812 - O

LAND-USE GRADIENT EFFECTS ON SOIL MICROBES: ARBUSCULAR MYCORRHIZAL FUNGI SHOW DISTINCT SENSITIVITY FROM NATURAL TO MANAGED SOILS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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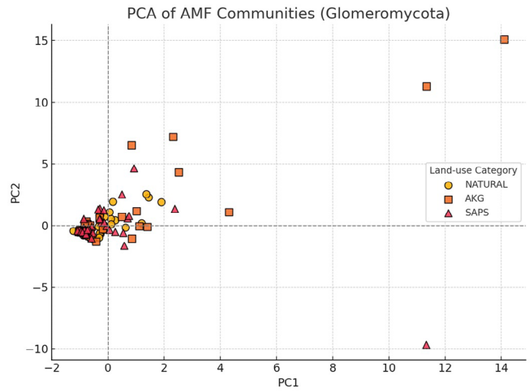
Soil microbial communities are key indicators of soil health and functioning, yet their variation across land-use types remains context-dependent. This study assessed fungal, bacterial, and arbuscular mycorrhizal fungal (AMF) communities in soils from 200 matched samples in Hungary. Each sample belonged to trio that included one undisturbed natural site, one conventionally managed site (SAPS), and one site under agri-environmental management (AKG), all close together, allowing paired comparison within the same local context.

Amplicon sequencing was used to characterize microbial communities. Principal Component Analysis (PCA) revealed that natural soils hosted compositionally distinct microbial assemblages across all three groups. For fungi, variation was more diffuse (PC1 = 2.2%, PC2 = 1.7%), with substantial overlap between AKG and SAPS sites, while natural sites formed a looser but recognizable cluster. Bacterial communities showed stronger separation (PC1 = 5.3%, PC2 = 3.9%), with natural samples forming a distinct group and AKG samples positioned between natural and SAPS clusters. The clearest land-use gradient appeared in the arbuscular mycorrhizal fungi (AMF) community (Glomeromycota), where PC1 and PC2 explained 6.3% and 5.4% of the variance, respectively. Here, natural samples formed a tight and distinct cluster, SAPS samples diverged markedly, and AKG samples were again positioned intermediately—suggesting greater sensitivity of mutualistic fungal groups to land-use intensity and the potential buffering effect of agri-environmental management.

To assess intra-site dynamics, we evaluated each trio's structure in ordination space. Centroid deviation analysis showed that SAPS samples were on average farthest from their trio's central community profile, while natural samples were closest, with AKG consistently intermediate. Within-trio dispersion analysis supported this pattern: although most trios exhibited similar microbial profiles, a few showed highly divergent AMF compositions (mean pairwise distance = 1.19, max = 28.5), highlighting context-specific disruption or resilience.

Dominant AMF taxa varied between land-use types, suggesting functional filtering: Glomus macrocarpum and Claroideoglomus drummondii were more abundant in AKG sites, Funneliformis caledonium and Cetraspora gilmorei in SAPS, and Redeckera pulvinatum and Claroideoglomus claroideum in natural areas.

By controlling for site-specific variation through the trio structure, this study offers robust evidence that natural reference soils are compositionally unique, and that mycorrhizal fungi may serve as functionally meaningful indicators for soil monitoring. These insights contribute to the design of agroecological strategies aligned with the EU Soil Mission.





GT 04 - 853 - O

DEPTH-RESOLVED MONITORING OF ARBUSCULAR MYCORRHIZAL FUNGAL COMMUNITIES DURING TRANSITION TO REGENERATIVE AGRICULTURE

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Monitoring soil health is essential for sustainable agricultural productivity and mitigating the environmental impacts of land use. Soil degradation—including erosion, loss of organic matter, and declining biodiversity—is closely linked to intensive agricultural practices. According to EU agri-environmental indicators, conventional tillage, characterized by frequent ploughing and harrowing, leads to soil disturbance, compaction, and reduced biological activity. This highlights the need to promote reduced or no-tillage systems to maintain soil function and biodiversity.

Among biological indicators, arbuscular mycorrhizal fungi (AMF) play a key ecological role. These fungi form symbiotic associations with most terrestrial plants, enhancing nutrient uptake, supporting soil structure, and increasing plant stress resilience. However, AMF communities are highly sensitive to tillage, fallowing and other anthropogenic disturbances, and their decline under conventional practices represents a major loss of ecological function.

Despite their importance, AMF and other microbial communities remain underrepresented in national and EU-wide soil health surveys, where assessments largely focus on physical and chemical properties of the topsoil (0–15 cm). Yet, subsoil layers host diverse microbial communities and processes essential for long-term soil health and fertility. Emerging research shows that focusing solely on the topsoil can lead to incomplete assessments, especially considering the spatial and biological heterogeneity of soils. Integrating microbial indicators—particularly AMF—into multi-depth monitoring strategies would improve our understanding of soil responses to land use and inform more effective agri-environmental policy.

The study investigates shifts in microbial and AMF communities following the transition from conventional to regenerative agricultural practices. The conventionally managed site is ploughed but left uncovered, while the regenerative site is no-till and uses cover crops before seeding. Monitoring began immediately after the transition in 2024, with quarterly sampling guided by the area's digital soil map. Soil samples are collected at five depth intervals (0–10 cm, 10–20 cm, 20–30 cm, 30–40 cm, 40–50 cm) to capture vertical variation. This study aims to assess how regenerative practices influence AMF communities across soil depths and to contribute to the development of improved biological indicators for soil health monitoring.

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GT 04 - 860 - O

GREENHOUSE GAS FLUXES MEDIATED BY BIOCRUST TYPE IN SEMIARID ECOSYSTEMS

GT 04. SOIL BIOLOGY / GT 04. SOIL BIOLOGY

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Greenhouse gases (GHGs), including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are major contributors to anthropogenic climate change. In drylands, biological soil crusts (biocrusts) mediate soil–atmosphere gas exchanges through respiration, photosynthesis, and nitrogen fixation. While they contribute to C and N sequestration, biocrusts also stimulate heterotrophic respiration and influence GHG emissions. These effects depend on biocrust type, composition, and disturbance, which can suppress microbial activity and alter GHG fluxes. Biocrust restoration via soil inoculation with native cyanobacteria may help re-establish key soil functions, including GHG flux regulation, but the effects of such induced biocrusts remain poorly studied. Additionally, while CO_2 fluxes have been examined more extensively, CH_4 and N_2O fluxes in biocrust systems are still underexplored.

This study evaluated CO_2, CH_4, and N_2O fluxes across natural and induced biocrust types under contrasting conditions in the semiarid Tabernas Desert (SE Spain). Natural biocrusts included: (1) bare soil, (2) dark biocrusts (dominated by cyanobacteria and cyanolichens), and (3) lichen biocrusts (dominated by Diploschistes diacapsis and Squamarina lentigera). Induced biocrusts were generated through soil inoculation with native cyanobacteria (Nostoc commune and Tolypothrix distorta). Gas fluxes were measured using static opaque chambers placed over 10-cm diameter PVC collars inserted 5 cm into the soil. Air samples were collected at 0, 10, 20, and 30 minutes across different seasons and analyzed via cavity ring-down spectroscopy (CRDS) to quantify CO_2 and CH_4 concentrations and isotopes ($\delta^{13}CO_2$, $\delta^{13}CH_4$), as well as N_2O and its isotopomers ($\delta^{18}O$, $\delta^{15}N$, $\delta^{15}N\alpha$, $\delta^{15}N\beta$). Soil temperature and moisture were also recorded.

We observed consistent differences among biocrust types. Cyanobacteria- and lichen-dominated biocrusts showed significantly higher CO_2 emissions than bare soil and induced crusts, reflecting elevated metabolic activity. All treatments acted as CH_4 sinks, with the highest uptake in well-developed natural crusts. Induced biocrusts showed intermediate CH_4 uptake, higher than bare soil, suggesting that cyanobacterial inoculation may enhance CH_4 sink strength. N_2O fluxes were low and variable across treatments, indicating limited contributions to N_2O emissions under the studied conditions.

Our findings highlight the dual role of biocrusts in carbon emissions. Importantly, cyanobacteria-based restoration improved CH_4 uptake, supporting the use of biocrust inoculation in climate-resilient restoration strategies.

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GT 04 - 964 - O

EFFECT OF COMPACTION ON THE NUMBER AND MORPHOLOGY OF GROUND-NESTING BEE BURROWS.

GT 04. SOIL BIOLOGY / GT 02. SOIL PHYSICAL CHEMISTRY

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Agricultural intensification has escalated soil compaction through mechanized tillage, degrading critical habitat for ground-nesting bees—which constitute 75% of bee species and deliver vital pollination services. Despite evidence that bees preferentially excavate softer soils, recent studies report species-specific adaptations to compacted substrates, creating a paradox requiring mechanistic resolution. To address this, we employed X-ray computed tomography (XRCT) for non-destructive 3D quantification of burrow architecture under compaction gradients in China's black soil region.

Specifically, field experiments imposed three treatments: uncompacted control (CK), mild compaction (C1: 5 tractor passes), and severe compaction (C2: 10 passes), with stratified soil properties (penetration resistance, shear strength, bulk density, moisture) measured across 0–40 cm depths. Using high-resolution XRCT scanning (85 µm resolution), 18 intact burrow systems were reconstructed, enabling precise morphological analysis of burrow volume, depth, branching, and soil plug distribution.

Crucially, results demonstrated that severe compaction (C2) catastrophically reduced burrow density by 84.3%, confirming behavioral avoidance of compacted soils. Beyond abundance declines, C2 triggered structural simplification: burrow volume decreased 33.5%, branch counts dropped 36.2%, and depths shallowed 28.4%. Mechanistically, correlation analyses revealed surface layers (0–5 cm) strongly inhibited lateral expansion, where branch width correlated negatively with bulk density and moisture. At 5–10 cm depth, shear strength >150 kPa further constrained vertical excavation, indicating energy-allocation trade-offs.

Notably, XRCT visualization uncovered a compaction-induced shift in soil plug positioning: while CK and C1 plugs localized at branch termini, C2 plugs clustered within main tunnels—a phenomenon attributed to mandibular fatigue in denser soils. Intriguingly, reproductive metrics (egg volume, chamber size) remained unaffected, suggesting bees prioritize reproductive investment over architectural complexity under stress.

Collectively, this study establishes XRCT as a transformative tool for subterranean ethology, while demonstrating that compaction thresholds (bulk density >1.4 g/cm³, shear strength >150 kPa) critically degrade nesting habitats. To conserve pollinators, we recommend minimizing tillage passes and preserving uncompacted field margins—strategies requiring validation through species-specific tolerance mapping via XRCT-enabled monitoring.

GT 04 - 14 - F + P

BIOCHAR EFFECTS ON ANT COMMUNITY COMPOSITION IN ENRICHED SECONDARY FORESTS OF THE ECUADORIAN AMAZON

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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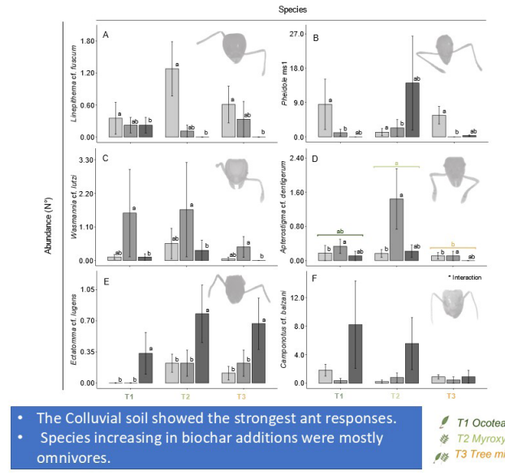
Ants are among the most abundant and ecologically important members of the invertebrate community in tropical forest ecosystems. They are important soil ecosystem engineers and potential bioindicators in restoration processes. Ants have been found to show a distinctive species pool in ancient soils enriched with biochar, known as anthropogenic dark earths [1]; however, ant responses to modern biochar applications in tropical forests have not been assessed. We investigated ant community responses to additions of two types of biochar in an Amazonian secondary forest enrichment planted with non-timber forest product (NTFP) trees, predicting that ant diversity would be reduced with increasing soil nutrients after biochar addition, following the homogenization hypothesis, while fungivore Attini ants would decrease due to the liming effects of biochar. Over three years of ant collection, I found that ant communities varied mainly with time and soil types, with no strong evidence for community homogenization in response to biochar. Kiln biochar significantly reduced overall ant abundance by 14%, also reduced by mound biochar by 9.5%; however, some genera of scavengers such as Crematogaster showed large increases with kiln biochar addition. Contrary to my predictions, in the colluvial soil, Attini ants such as Atta also showed large increases in plots amended with mound biochar. Here, omnivore ants, including Ectatomma cf. lugens and Camponotus cf. balzani increased in mound biochar-amended plots by >4-fold, Wasmannia cf. lutzi increased by 5-fold in kiln biochar plots. NTFP treatments also had large effects on ant communities, especially in the alluvial soil, where NTFP plantations had a larger effect than biochar on the Attini ants, while in the colluvial soil, Attini increased by >10-fold in mixed NTFP plantations relative to controls. Given the very long persistence of biochar in the soil, this study suggests that biochar amendments may alter the ant community in the long run, but that these effects are relatively small compared to the effects of soil type or forest successional status.

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- The Colluvial soil showed the strongest ant responses.
- Species increasing in biochar additions were mostly omnivores.

T1 Ocotea quixos
T2 Myroxylon balsamum
T3 Tree mixture

Ant species to biochar addition



GT 04 - 372 - F + P

BELOWGROUND BIODIVERSITY DYNAMICS DURING WOODLAND DEVELOPMENT: INSIGHTS FROM A UK FOREST CHRONOSEQUENCE STUDY

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Woodland creation and afforestation are critical strategies for addressing climate change and biodiversity loss, yet the belowground processes crucial to forest ecosystem health remain understudied. Our research investigated how woodland development influences soil biological communities and their functions across a unique chronosequence of UK woodland sites (20-160 years), comparing them with ancient woodlands (250+ years) and adjacent pastures. We examined three key components of soil biodiversity: microbial communities, earthworm populations, and fine root traits. Our findings reveal distinct successional patterns in soil biological communities that parallel aboveground woodland maturation.

Microbial community analysis demonstrated that older woodlands support unique ectomycorrhizal fungal assemblages, with community composition strongly influenced by both tree species and woodland age. We identified specific fungal taxa as potential bioindicators for different forest succession stages, providing valuable insights into their ecological roles within woodland ecosystems.

Earthworm community structure showed significant transitions during woodland development, with endogeic (soil-dwelling) earthworms declining while epigeic (litter-dwelling) earthworms increased in relative abundance as woodlands matured. Species diversity peaked in the oldest woodlands, with woodland age and ground cover vegetation emerging as significant environmental factors influencing earthworm population dynamics.

Root trait analysis revealed a reduction in specific root length as woodlands matured, suggesting an evolutionary shift from efficient resource uptake strategies toward more conservative resource utilization. These changes in fine root morphology coincided with transitions in microbial symbiotic relationships and soil carbon distribution patterns.

Importantly, these belowground biodiversity changes corresponded with significant increases in soil organic carbon storage. Woodland sites stored more soil organic carbon than neighbouring pastures, with old-growth forests showing a fourfold increase. Carbon levels in soil aggregates varied with woodland age, with sites aged 81-160 years showing higher carbon concentrations in microaggregates and finer soil particles compared to pastures.

This research provides a comprehensive understanding of belowground ecological changes during woodland creation and succession. Our findings highlight the complex interrelationships between soil biodiversity components and their collective contribution to ecosystem functions such as carbon sequestration. These insights can inform forest management and restoration practices to enhance soil biological health, biodiversity, and the long-term sustainability of forest ecosystems in the UK and similar temperate regions.

GT 04 - 425 - F + P

AGROPHOTOVOLTAIC SYSTEM SHAPES SOIL ARTHROPOD COMMUNITY STRUCTURE: INTERACTIONS BETWEEN MICROCLIMATE, CROP DEVELOPMENT, AND EDAPHIC FACTORS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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AgroPhotoVoltaic (APV) systems, which integrate solar panels with agricultural production, present a promising solution to the increasing competition for land between food production and renewable energy. While the effects of APV on crops and the broader environment are well-documented, their impact on soil biodiversity—particularly on soil arthropods—remains under-explored. Soil arthropods are vital for maintaining soil health, contributing to nutrient cycling, soil structure development, and pest regulation. Despite their importance, how APV affect these communities, especially in relation to microclimatic shifts and changes in soil properties driven by solar panel shading, is poorly understood.

This study, part of the SUNRISE PNRR project – n. P2022ALZMM, aimed to evaluate the impact of APV on soil arthropods. Conducted at an APV site in northern Italy, the research used a REM Tec Agrovoltaico® 3D horizontal bi-axial solar tracker with two different shadow levels: standard trackers (13% shading), expanded trackers (41% shading). 4 treatments were evaluated: crops shaded by standard and expanded trackers, full sun, and a control area (grass). Durum wheat and tomato crops were selected for the study, with wheat assessed under all four treatments and tomato under three (without expanded trackers). Soil samples were taken over multiple growing seasons to analyse soil pH, organic matter content, and soil respiration, which serve as indicators of microbial activity.

The results demonstrated significant variation in arthropod community composition across crop types, crop development stages, and soil temperatures. Notable differences were observed between wheat and tomato, particularly across their developmental stages, with both crops showing distinct shifts in arthropod community composition when compared to the control. Indicator analysis revealed specific arthropod orders closely linked to crop stages, such as Thysanoptera and Polyxenida in early wheat stages, and Isopoda in late tomato stages. Further analysis indicated that the interaction between crop type and developmental stage significantly influenced community variations, with shifts in communities across different treatments in both wheat and tomato. Collembola communities, dominated by Isotomidae and Entomobryidae, were shaped by factors such as soil organic matter and moisture content. Collembola diversity metrics also indicated significant treatment effects, with control plots supporting higher species richness and evenness, especially in wheat.

These results highlight the complex interactions between crop type, soil properties, and arthropod communities, underscoring the need for more research on the ecological implications of APV. The findings suggest that APV can significantly influence soil biodiversity and ecosystem functioning, particularly through agricultural practices, with important implications for ecosystem management and biodiversity conservation in agricultural landscapes.



GT 04 - 586 - F + P

INNOVATIVE CRISPR SOLUTIONS FOR OPTIMISING NITROGEN MANAGEMENT IN AGRICULTURE - ICON

GT 04. SOIL BIOLOGY / GT 04. SOIL BIOLOGY

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The nitrogen (N) cycle driven by microbial activity, is responsible for the conversion of N-fertiliser to forms of N which can be beneficial for crop assimilation, or damaging to farm economic performance, health and the environment.

ICON is a collaborative project between GAIN Holdings Ltd (GAIN) and the John Innes Centre (JIC) that will bring together proprietary CRISPR/Cas-based microbiome engineering technology (GAIN) and expertise in soil microbiology and soil N transformation measurements (JIC) for the design-led biological control of key steps in the soil N-cycle.

ICON will deliver proof-of-concept prototypes for the control of key steps in the soil N-cycle. The project focuses on developing new agricultural biological products that will enable farmers to sustainably inhibit ammonification, nitrification, and denitrification processes in their soils. This innovation is expected to increase plant N use efficiency, reduce the need for synthetic fertilisers, and minimise environmental pollution by ammonia, nitrates, and nitrous oxide (N2O), a greenhouse gas 300 times more potent at trapping heat in the atmosphere than CO2.

The expected benefits of the project are: i) Increased Nitrogen Use Efficiency: Reducing synthetic fertiliser inputs; ii) Environmental Protection: Lowering emissions of harmful pollutants; and iii) Sustainable Agriculture: Promoting soil health and microbial diversity.

Additional benefits will come from the biological nature of these products and their precise mode of action, enabling a step-change in sustainable N management practice, providing farmers with tools to regenerate their soils and increase beneficial microbial diversity.

The project targets key UK mandates regarding control of N emissions from agriculture (DEFRA COGAP for Reducing Ammonia Emissions, 2024; UK Net Zero Strategy, 2022; UK Agricultural Transition Plan, 2024) and addresses key aspects of the UK KTN Microbiome Innovation Network's Strategic Roadmap, with the primary aim of enabling farmers to efficiently manage N in a sustainable way by controlling the soil microbiome. Resulting products align with the industry moving towards more sustainable, biological, tools for N management that will enable farmers to comply with increasing regulatory/sustainability requirements both in the UK and internationally.

GT 04 - 760 - F + P

TREE SPECIES AND SOIL HORIZONS SHAPE FUNGAL COMMUNITIES IN ITALIAN BEECH AND SPRUCE FORESTS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Soil fungal communities are essential drivers that sustain forest ecosystem balance, mediating nutrient cycling, organic matter decomposition, and plant symbioses. However, their spatial and seasonal dynamics, especially regarding tree species identity and soil horizon stratification, are still insufficiently characterized. In this study, we conducted a comparative analysis of soil fungal communities at two Italian forest sites: one in the Dolomites (Pedavena), containing adjacent pure stands of European beech (Fagus sylvatica) and Norway spruce (Picea abies), and one in the Apennines (Camaldoli), hosting a beech-dominated forest. We employed internal transcribed spacer (ITS) metabarcoding across spring, summer, and autumn, and analyzed fungal communities in both organic and mineral horizons. Soil chemical properties were assessed in spring to contextualize microbial patterns. Fungal community composition clustered distinctly by forest type and soil layer, with tree species and site exerting a greater influence than seasonal variation. Richness and evenness were consistently higher in organic horizons and in the Camaldoli beech forest, indicating more diverse and functionally balanced communities near the surface. In Pedavena, beech stands supported significantly higher fungal diversity than adjacent spruce stands. Dominant fungal phyla included Ascomycota and Basidiomycota, with saprotrophic genera such as Aspergillus and Penicillium prevailing in Camaldoli, suggesting active decomposition processes. In contrast, ectomycorrhizal taxa were abundant in Pedavena, especially in the spruce forest and organic horizon, and were most prominent in spring and autumn. Functional annotation via FUNGUILD highlighted striking site-specific ecological strategies, with Camaldoli exhibiting a greater abundance of parasites, saprotrophs, and endophytes. Our findings demonstrate that fungal community structure is strongly shaped by tree species identity and soil stratification, with relatively minor seasonal effects. These patterns underscore the critical importance of forest composition in determining belowground biodiversity and functional potential, offering new insights into the resilience and biogeochemical functioning of temperate forests under changing environmental conditions.

GT 04 - 119 - P

STRUCTURAL AND FUNCTIONAL SHIFTS IN BACTERIAL COMMUNITIES IN HEAVY METAL-CONTAMINATED SOILS IN A GOLD-COPPER MINING AREA IN BULGARIA

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Aim: The goals were (i) to assess the bacterial community structural shifts in Bulgarian heavy metals/metalloids polluted soils, and (ii) to predict key metabolic pathways associated with heavy metal resistance of bacterial communities.

Material and methods: The object was the region of Zlatitsa -Pirdop Valley, Southern Bulgaria, which has a history of gold-copper mining activities over 70 years. Five subsamples along a gradient of Cu pollution (co-pollutants Zn and Pb) were collected from two soil depths: topsoil (0-20 cm: S1.1, S2.1, S3.1, S4.1, S5.1 and S6.1) and subsoil (20-40 cm: S1.2, S2.2, S3.2, S4.2, S5.2 and S6.2) layers.

Total DNA was extracted from 0.5 g of soil using the E.Z.N.A. DNA Soil Kit (Omega Bio-tek, USA) The targeted sequencing of 16S amplicons (V3–V4 region) was carried out and amplicon libraries were prepared and sequenced on an Illumina MiSeq platform (Macrogen, Seoul, South Korea) with a read length of 2×300 bp.

Main results: Soils were classified as clean (S1.1; S5.1; S1.2), warning limited (S2.1; S2.2; S5.2), slight (S6.1; S6.2), moderate (S3.1; S3.2; S4.2) and high polluted (S4.1) according to Nemerow pollution index (NPI). In a context of bioavailable HM concentrations, the potential ecological indeces (ERIs) were established as low (S1.1; S2.1; S1.2; S2.2), moderate (S3.1; S3.2), considerable (S6.1), very high (S5.1; S4.2; S5.2; S6.2) and disastrous (S4.1)

The results showed that the most abundant bacterial phyla across all samples were Actinomycetota, Pseudomonadota and Acidobacteriota, representing 57% to 76% of total sequence data. The most widespread and dominant classes in topsoils across were Actinomycetes in S1.1 (22.72%) and S6.1 (20.43%), Thermoleophilia in S4.1 (18.99%), and Alphaproteobacteria in S2.1, S1.1 and S5.1 (13.87-15.69%), while in subsoils were: Thermoleophilia in S4.2 and S1.2 soils (14.81-25.43%, respectively), and Alphaproteobacteria in S2.2, S3.2, S5.2 and S6.2 (15.06-17.10%).

Predicted functional shifts in the bacterial community were assessed using the KEGG database. The results showed that the KEGG abundance was highest in S6.1 and lowest in S5.1. A general trend indicated that topsoil samples typically showed higher KEGG abundances than their corresponding subsoil samples, particularly in highly represented metabolic pathways. An exception were S1 and S5, where the opposite trend was observed.

Conclusion: Bacterial community shifts were depth-dependent and more pronounced at the class than phylum level. Depth-dependence of phyla distribution was detected only in low abundance taxa. A similar trend was observed in the functional shifts of the bacterial communities, where topsoils showed more abundant metabolic pathways associated with HM resistance than their corresponding subsoils, particularly in highly represented metabolic pathways.

ACKNOWLEDGEMENTS

This study was financially supported by the Bulgarian Science Fund (Grant KP-06-N76/9/2023)

GT 04 - 120 - P

ECOLOGICAL ASSESSMENT OF HEAVY METAL-CONTAMINATED SOILS VIA MICROBIAL TAXONOMIC AND METABOLIC PROFILING IN THE TOPOLNITSA RIVER REGION, SOUTHERN BULGARIA

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Aim: This study aimed (1) to assess the taxonomic composition of bacterial communities, (2) to determine microbial metabolic profiles in heavy metal- contaminated soils from the Topolnitsa River region in Southern Bulgaria, and (3) to evaluate the ecological risk in this area. For this goal the targeted 16S rRNA gene amplicons sequencing and community level physiological profiling (CLPP) techniques was combined.

Material and methods: The region of Topolnitsa River is located in heavily industrialized area with extensive Cu, Zn, Pb, Cd, and As mining and processing. Topsoil samples were collected from five sites (S1-S5). Community-level physiological profiling (CLPP) and Average well color development (AWCD) were analyzed using the BiologEcoPlates™system [1]. The relationships between soils parameters, heavy metal concentration, AWCD, and diversity indices was performed. Taxonomic profiling was assessed via 16S rRNA gene metabarcoding targeting the V3–V4 region (MiSeq, Illumina; Macrogen, South Korea).

Main results: The Nemerov pollution index (NPI) classified soils as slightly polluted S1, S2, S3, and heavily polluted S4 and S5. The taxonomic composition comprised 17 phyla, showing varying distributions across the soils. Pseudomonadota, Acidobacteriota, and Bacteroidota were the most abundant.

Main bacterial classes identified were Alphaproteobacteria, Gammaproteobacteria, Terriglobia, Blastocatellia and Bacteroidia of the total 26 classes. The AWCD values reflected the microbial community's metabolic activity across the different sampling sites (S1–S5) with the relatively high in S2 and S5. SAWCD indicated some variations in their potential to catabolize the six groups of carbon sources AA, CA, CH, POL, AM and PHE. The most easily utilized group were as follows: CA> AA>AM>POL>CH >PHE (except S3).

The Pearson's correlation statistical test showed a strong positive correlation between Zn and As, also Cd and Pb. A perfect correlation was found between H' and E', indicating a close relationship between microbial diversity and community balance. Additionally, SM was positively associated with SR and with P_2O_5.

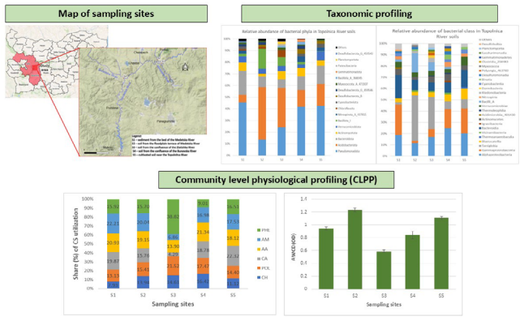
Conclusion: The 16S amplicon sequencing and CLPP enabled the assessment of taxonomic and metabolic profiles of long-term heavy metal-contaminated soils in the Topolnitsa River region. Shifts in bacterial community structure and metabolic activity were linked to local soil parameters and the impact of heavy metals. The results highlight that microbial profiling and activity could serve as indirect indicators for assessing the ecological risk in this area.

ACKNOWLEDGEMENTS

This study was financially supported by the Bulgarian Science Fund (Grant KP-06-N76/9/2023)

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Graphical abstract



GT 04 - 134 - P

SOIL NEMATODE COMMUNITIES IN NATURAL AND INVADED HABITATS: A COMPARATIVE STUDY ACROSS RIPARIAN AND GRASSLAND ECOSYSTEMS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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This study investigated soil nematode communities in riverbank and permanent grassland ecosystems across three geomorphological regions of Slovakia, focusing on the impact of two invasive plant species: Fallopia japonica and Solidago gigantea. The results indicated that in riparian habitats, site-specific factors influenced soil properties but had a minimal effect on nematode communities. In contrast, in permanent grasslands, site conditions had a lower impact on soil properties, while nematode communities showed significant differences in almost all evaluated parameters, particularly in the warmest and lowest-elevation sites. Invasive plants F. japonica increased soil pH and reduced the abundance of nematodes, particularly plant-parasitic nematodes. Additionally, its invasion negatively affected soil maturity indices and decreased nematode abundance in functional groups cp2, cp4, and cp5. Similarly, the invasion of S. gigantea increased soil pH. The abundance of bacterivore and fungivore nematodes increased, negatively impacting all evaluated maturity and selected functional indices. These findings underscore the need for environmental management strategies to mitigate the effects of invasive plant species on soil communities.

ACKNOWLEDGEMENTS

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GT 04 - 142 - P

INSIGHTS INTO THE EFFECTS OF INVASIVE TREE ACER NEGUNDO ON SOIL NEMATODE COMMUNITIES – A CASE STUDY

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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The ash-leaved maple (Acer negundo L.) is an invasive tree species of North American origin and one of the most aggressive alien plants inhabiting various forests throughout Europe, especially in riparian habitats. In such habitats dominated by open-canopy forests, the chances of successful invasion by introduced tree species such as A. negundo are greater than in other habitats. Three tree species, namely Acer negundo (invasive, no-native taxa), Fraxinus excelsior and Alnus glutinosa (as native representatives) in Morava River floodplain forest habitats were selected in our study. We investigated the composition of families, genera, trophic groups and functional guilds of soil nematodes under each tree species to assess nematode usefulness as indicators of the impact of alien tree species on native communities. The study was complemented by measuring basic soil physico-chemical properties. A total of 96 nematode genera (83 in A. negundo; 87 in A. glutinosa and 77 in F. excelsior), belonging to 52 nematode families, were recorded in the investigated floodplain forest sites, including the genus Aprutides, which has not been previously recorded in the Slovak Republic. The most abundant families were Alaimidae, Cephalobidae, Hoplolaimidae and Rhabditidae for all three clusters. Among genera, Helicotylenchus, Pratylenchus, Paratylenchus, Filenchus and Malenchus (as plant parasites), and Acrobeloides, Eucephalobus, Plectus and Rhabditis (as bacterivores) were the most abundant taxa. Most nematode genera occurred in the rhizosphere of all tree species, with few exceptions,e.g. the genus Monhystrella and Prodorylaimus were only found in clusters of ash-leaved maple, while the genus Hexatylus was only observed in alder clumps. A relatively high total nematode abundance and genera diversity across all tree species, which did not differ significantly, suggest that nematode communities benefited from the presence of all of them. Additionally, the measured soil properties did not differ significantly among the tree species ($p < 0.05$). Nevertheless, redundancy analysis identified a significant negative correlation between soil moisture content and abundance of several nematode genera, nematode trophic groups and functional guilds. The results indicated that invasive ash-leaved maple trees in the studied floodplain forests have no negative influence on the diversity and functional structure of soil nematodes. Although our data are the first study on the effect of ash-leaved maple on soil nematodes, the results indicate that ash-leaved maple may not pose a threat to the soil food web and soil nutrient pools, as also shown by physico-chemical analysis of soils and as is generally assumed for invasive plants. Due to the absence of nematological studies from A. negundo invaded habitats, a definite conclusion is impossible, but further studies may answer this.

ACKNOWLEDGEMENTS

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GT 04 - 158 - P

SOIL MESO AND MACROFAUNA DIVERSITY IN A SECONDARY MEDITERRANEAN SHRUBLAND ALONG A WATER AVAILABILITY GRADIENT

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Climate change scenarios foresee profound impacts on ecosystem functioning mostly due to changes in precipitation volumes, intensities and spatial and temporal distributions of rain events. Extreme drought events are expected to increase both in intensity and frequency. Mediterranean drylands, instead of historically coping with water scarcity and uneven precipitation patterns, are especially sensitive to these changes. Soil meso and macrofauna (body size > 0.2 mm) are key components of the ecosystem with especial role in litter decomposition, soil structure, and nutrient cycling and resource availability. For this reason, the responses of this essential component to climate change are crucial at the ecosystem scale.

We have assessed the effects of seven years of different water availability on soil meso and macrofauna in a mature shrubland dominated by obligate seeder species under dry mediterranean field conditions. Experimental treatments included severe drought (80% water reduction), drought (40% reduction), control, and watering (10% water addition). Drought treatments were implemented by fixed rainout shelters that covered 100% soil surface. Plot size was 2 x 2 m with a 0.50 m buffering zone. A sprinkler system applied irrigations at a rate of 1 L m-2 min-1. Treatments, replicated 3 times, started in November 2016.

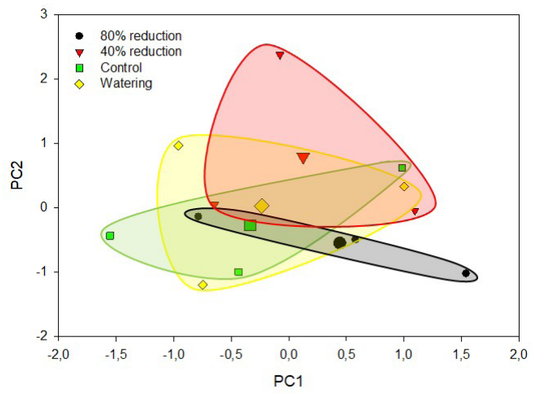
In spring 2024, we assessed the abundance and diversity of soil fauna by installing two pitfalls per plot. These traps contained half of their volume with water and propylene glycol (3:1) to conserve individuals and avoid attractive chemicals. Samples were collected after 1 week in the field and carried to the laboratory in facilities of the University of Alicante for individual identification.

We collected and identified 3545 individuals from 20 orders/groups and 29 families. Orders/groups with higher number of individuals were Collembola (535.4 ± 284.4), Hymenoptera (41.9 ± 7.1), predator mites (13.0 ± 2.5) and Hemiptera (11.7 ± 3.7). We found a not significant trend to decrease the number of individuals as drought increased: watering (352.4 ± 282.6), control (169.5 ± 26.7), and water reduction (66.2 ± 7.5 and 64.5 ± 8.0, in 80% and 40% reduction, respectively). Shannon's diversity index showed a not significant trend to increase at both extremes of the gradient, with the lowest value in the controls (0.754 ± 0.136) and the highest in 80% reduction (1.367 ± 0.191).

The observed decrease in Collembola and Oribatida with increased drought is in line with other studies, demonstrating that soil microarthropods can be useful indicators of collapse. Our results indicate that the change of abundance and diversity of soil meso and macrofauna follow a humpback curve rather than a linear decrease.

ACKNOWLEDGEMENTS

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PCA with soil meso and macrofauna abundances in relation to water availability

GT 04 - 180 - P

THE EFFECT OF GLYPHOSATE-BASED HERBICIDES ON SOIL MESOFAUNA IN APPLE ORCHARD SYSTEMS IN PORTUGAL

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Apple orchards (Malus domestica) are a key perennial crop in Portugal, occupying significant areas in the western region, where they hold considerable economic and social value. However, weeds pose a substantial challenge in these systems, often leading to economic losses.

The common method of weed control involves the use of glyphosate-based herbicides, whose in-creasing use has raised concerns about potential negative effects on soil health, including disturb-ances to key edaphic groups such as soil mesofauna. Despite growing interest in these impacts, exist-ing methodologies for assessing soil quality have been complex and lacking standardized approaches.

This study, conducted in 2024, aimed to assess the effects of glyphosate-based herbicides on soil mesofauna in two orchard fields (a and b) in western Portugal. In field a, samples were collected be-fore and after herbicide application, while in field b, samples were compared between herbicide and mechanical weed control treatments.

Soil samples were evaluated using the QBS-ar methodology, which classifies soil biological quality based on mesofauna composition. The results indicated a reduction in mesofauna populations follow-ing herbicide application, suggesting potential drawbacks of glyphosate-based herbicides compared to mechanical control methods.



GT 04 - 189 - P

THE IMPACT OF WATER EROSION ON SOIL INVERTEBRATE COMMUNITIES AT DIFFERENT SLOPE POSITIONS: A COMPARATIVE STUDY FROM VARIOUS MANAGEMENT SYSTEMS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Water erosion significantly affects agricultural soils worldwide, influencing not only their physical and chemical properties but also soil biodiversity, which is substantially less documented. This study examines the relationship between water erosion and soil invertebrates at different slope positions in agricultural landscapes. Our five-year research was conducted at 18 sites in the chernozem region of the Czech Republic under conventional farming. Each site was divided into three distinct zones: control, erosional, and depositional areas. Using traps, we collected and analyzed over 92,000 individuals from six model taxa: ground beetles, spiders, harvestmen, centipedes, millipedes, and woodlice. Statistical analysis revealed that the distribution of soil invertebrates was not driven by passive transport alone. The study demonstrated that erosion processes affect soil fauna communities both directly through physical displacement and indirectly through habitat modification involving changes in soil texture, organic matter content, and soil chemistry. The greatest differences in invertebrate abundance were found between erosional and depositional zones. Different patterns were observed among various organism groups. For example, myriapods and spiders were negatively affected by erosion intensity and tended to accumulate in depositional parts of the slope (passive water transport and preference for areas with higher organic matter content). Ground beetles showed more uniform distribution, preferring areas with weaker erosion, and their high dispersal potential suggests a process of "recolonization" of erosional slope parts. The study suggests that erosion control measures should consider not only soil physical and chemical properties but also their impact on soil biodiversity. Understanding the relationship between erosion processes and soil fauna distribution can help develop more effective and ecologically sensitive erosion control strategies that maintain both soil productivity and biodiversity in agricultural landscapes. A practical example is the effective soil protection through strip cropping, which has been applied in recent years in the described chernozem areas over considerable areas, where according to our new results, the actual erosion rate is reduced to approximately one-third. This significantly affects the distribution of ground-dwelling invertebrates, as shown by models explaining their occurrence patterns, where the erosion factor in this agricultural system does not reach statistical significance. The examples from both described types of agricultural management will present the effects of erosion on invertebrate communities as important components of agroecosystems.

ACKNOWLEDGEMENTS

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GT 04 - 242 - P

MICROORGANISMS IN AN EXTREME WORLD: ACTINOBACTERIA DOMINANCE IN HIGHLY HEAVY METAL-CONTAMINATED ACIDIC SULFIDE MINE TAILINGS

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Acidic sulfide mine tailings represent one of the most severe forms of post-mining land degradation, with widespread heavy metal contamination that threatens soil health, ecosystem resilience, and human safety. However, microbial communities persist and drive critical biogeochemical processes in these extreme environments. Yet, mechanistic interplay between metal mobility, geochemical stressors, and microbial resilience remain poorly understood, limiting the scalility of bioremediation strategies. This study integrates geochemical profiling, sequential metal fractionation, and microbial metabarcoding to identify the environmental drivers shaping microbial community structure in acidic mine tailings and proposes predictive frameworks for environmental risk mitigation. Investigations at the Kettara sulfide tailings brownfield (Morocco) revealed pronounced spatial variability in pH (2.24–7.13), electrical conductivity (0.067–4.82 mS/cm), and bioavailable heavy metal, with hotspots of Cu (753.7 mg kg^{-1}) and Zn (45.9 mg kg^{-1}) exceeding ecological risk thresholds by 12-40-foldunder extremely acidic locations (pH < 3.5). Metabarcoding revealed a dominance of Actinobacteriota (46.9%) and Proteobacteria (14.6%), with stress-tolerant taxa such as Rubrobacter (5.8%) and Deinococcus (10.6%) being prevalent in high-metal niches with low pH values. Redundancy analysis linked microbial community assembly to pH-driven shifts in metal bioavailability (Cu, Cd, and Zn) and nitrogen limitation, revealing a pH-dependent trade-off between metal resistance and oligotrophic adaptation. These findings challenge the assumption that acidic tailings uniformly select for acidophiles, instead revealing geochemical thresholds that enable heterotroph-driven soil rehabilitation. By coupling microbial resilience patterns with metal mobility dynamics, we propose a generalizable bioremediation framework prioritizing bioavailability reduction reached through pH improvement over total metal loads.

ACKNOWLEDGEMENTS

We would like to thank Alexander von Humboldt Foundation for financial support and Heidrun Kerkhoff, Katja Gonschorek, and Sabine Frölich from the Laboratory of the Institute of Geography at Ruhr University Bochum for their great help during this experiment.



GT 04 - 314 - P

UNLOCKING SOIL NITROGEN DYNAMICS: THE ROLE OF SOIL FAUNA IN SOIL-PLANT MESOCOSM SYSTEMS WITH VARYING INPUTS

GT 04. SOIL BIOLOGY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Optimizing soil nutrient cycling is an important activity in sustainable agriculture. Leaving crop residues on the land after harvesting reduces soil nutrient loss and increases soil organic material. Soil microorganisms play an important role in nutrient cycling during the decomposition of crop residues. However, during the decomposition process of low-nitrogen cereal straw, plants face a period of nitrate depression, when the soil microbiota removes nitrogen from soil to compensate for this limited nitrogen content. In the complex soil food web, decomposition is not exclusively driven by soil microbiota. Soil fauna, such as nematodes and microarthropods, also play a crucial role, primarily by feeding on microbial communities and thereby influencing their activity. Despite their importance, soil fauna are often overlooked in agro-ecological studies, which typically focus more narrowly on microbial processes.

In a mesocosm experiment, we investigated the role of soil-dwelling nematodes and microarthropods in nitrogen cycling. In the spring of 2024 and 2025, semi-closed mesocosms were constructed on two soil types (calcareous chernozem and calcareous sandy soil), which included soil-plant (barley, Hordeum vulgare) system. The basic treatment in both years was to remove the soil-dwelling mesofauna from half of the mesocosms by drying, and thus compare soil-plant systems with fauna (faunated) and without fauna (defaunated). In 2024, an additional treatment was the presence or absence of crop residue in mesocosms. In 2025, all mesocosms contained crop residues, but half of the mesocosms were treated with mineral nitrogen fertilizer. During the experiment, water-soluble and exchangeable ammonium and nitrate ion content of the soil were monitored.

The soil fauna in defaunated mesocosms was much poorer than in faunated mesocosms. With poorer soil fauna, barley yields and soil microbial activity were lower and soil nitrate contents were different compared to the faunated mesocosms. The soil fauna also influenced the decomposition of crop residue and the community-level physiological profiles of the microbiota. These differences also depended on the soil type. The addition of crop residues reduced barley yield, increased soil microbial activity, and influenced soil fauna composition. In the 2025 experiment, the addition of mineral nitrogen fertilizer presumably reduces nitrate depression after the addition of crop residue, which might be influenced by the presence of soil fauna.

Soil-dwelling fauna have played an important role in soil nitrogen-cycling. By altering the activity of soil microbiota and thereby the decomposition of crop residues, soil fauna influence the nitrogen mineralisation and immobilisation processes and thus, the N-uptake and yields of barley plant.

ACKNOWLEDGEMENTS

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GT 04 - 321 - P

THE EFFECTS OF IVERMECTIN ON NON-TARGET SOIL-LIVING NEMATODES - LABORATORY STUDIES

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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This study examines the ecotoxicological effects of ivermectin, a widely used veterinary antiparasitic drug, on free-living soil nematodes, focusing on species-specific stress responses under changing environmental conditions. Although ivermectin is well-documented for its adverse impact on macroinvertebrates, its effects on soil microfauna remain poorly understood. Due to their abundance, functional diversity and sensitivity to pollutants, free-living nematodes offer substantial potential as bioindicators of soil contamination. Laboratory-based experiments were conducted on two nematode species: Panagrellus redivivus (a free-living bacterivore) and Xiphinema vuittenezi (a plant-parasitic nematode). These organisms were exposed to varying concentrations of ivermectin (1 to 1000 µg/l), with further calculations under modified conditions involving sonication and temperature levels (4 ° C, 20 ° C, and 30 ° C). Endpoints included survival rate and movement activity, the latter serving as a sublethal behavioural indicator. Results showed apparent dose-dependent toxic effects from ivermectin, with P. redivivus responding more sensitively, particularly in movement, at concentrations ≥100 µg/L. X. vuittenezi displayed higher survival, suggesting cross-species differences in tolerance. Elevated temperatures and prior sonication significantly enhanced ivermectin's toxicity, demonstrating that environmental factors and formulation methods control its biological impact. Statistical analysis (factorial ANOVA and Tukey HSD) confirmed the significant effects of ivermectin concentration, temperature, and sonication on nematode response. Notably, motility was a more sensitive indicator than survival, supporting its use in ecotoxicological evaluations. These findings emphasise the utility of nematodes, especially P. redivivus, as early-warning indicators of soil pharmaceutical contamination. Furthermore, the findings suggest that integrating nematode-based bioassays into environmental monitoring frameworks can enhance soil quality assessment and support the sustainable use of veterinary drugs. Future research should explore chronic effects, field-based validation and interactions with soil microbiota to improve risk assessments under realistic conditions.

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GT 04 - 327 - P

SOIL BIODIVERSITY–ECOSYSTEM FUNCTIONING RELATIONSHIP ACROSS CONTRASTING GRASSLAND SOILS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Given the biodiversity crisis, research on soil biodiversity and ecosystem functioning (BEF) has grown rapidly. While a positive BEF relationship is often reported, whether it holds across different soils associated with distinct soil and plant communities remains understudied. This study examined if the link between the presence and richness of broad soil functional groups and ecosystem functioning is consistent across grasslands with different soil characteristics and identified functions most affected by biodiversity decline.

We conducted a greenhouse experiment simulating five contrasting grasslands, each containing four biodiversity levels established by sequential filtering of the field soil community by size, creating a gradient in their presence, richness and thus community completeness. We then analysed functions related to biomass production, nutrient cycling, and microbial interactions.

The findings demonstrated that shoot biomass and microbial respiration remained unaffected by treatments, while nitrification potential and microbial nitrogen content increased with biodiversity loss across most soils. However, higher soil biodiversity led to a decrease in plant nitrogen content and soil urea degradation potential, suggesting that soil biodiversity may influence competition for nitrogen between plants and microbes. Moreover, while microbial biomass carbon and bacterial chemoheterotrophs were promoted by soil biodiversity in more fertile grassland soils, these variables and root biomass were reduced in poorer soils.

Our findings highlight that soil biodiversity can promote certain ecosystem functions while suppressing others and that the direction of these trade-offs may depend on the soil type. The conservation and management of soil biodiversity thus need to be evaluated in the context of the functions that are to be maximised and the grassland soil context.

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GT 04 - 375 - P

SEEKING THE OPTIMAL METHOD FOR SELECTIVE REMOVAL OF SOIL NEMATODES TO STUDY THEIR FUNCTIONAL ROLES: ENSURING EFFICACY WHILE MINIMIZING SOIL DISRUPTION

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil nematodes are widely recognized for their key roles in a variety of soil processes, such as carbon and nutrient cycling, and the regulation of microbial activities. Their direct and indirect effects on soil processes can be studied by comparing sterilized soils (nematode-free) with sterilized soils that have been reinoculated with nematodes. An optimal partial sterilization technique should selectively eliminate soil nematodes while minimizing impacts on other soil microorganisms and the physicochemical properties of the soil. Although various methods have been applied across different soils worldwide, there remains a lack of systematic evaluation of their efficiency and side effects, highlighting the need for a fast, accessible, cost-effective, and repeatable approach.

This study evaluated several different methods for the selective removal of nematodes, including dry heat, microwaving, freezing-thawing cycles, and gamma irradiation. In the first stage, their effectiveness was tested on sandy loam soil by assessing nematode abundance in both bare and planted microcosms, which were incubated for two and eight weeks, respectively. The effective methods were three freeze-thaw cycles (-80 °C to 22 °C for 72 h each) and microwave irradiation for 135 seconds (800 W, 2450 MHz).

In the second stage, these effective methods were tested in soils with light (loamy sand) and heavy (silt loam) textures, not only for their repeatability but also for their side effects on the physical, chemical, and biological properties of soils. Leaching and pulverized soil powder inoculation were also tested for their effects on mitigating nutrient flushes and restoring the soil microbial community after partial sterilization. Side effects were evaluated immediately after treatment and again after six weeks of incubation, through measurements of nitrogen mineralization, basal respiration, dissolved organic carbon, microbial biomass carbon, and the enzymatic activities of β-glucosaminidase and β-glucosidase. This part of the investigation is still ongoing; however, detailed results from the second stage will be available and presented at the conference.



GT 04 - 392 - P

AGRICULTURAL SOIL MANAGEMENT INFLUENCES SOIL BIODIVERSITY ACROSS DIFFERENT DEGRADATION GRADIENTS IN A SEMIARID AREA

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Unsustainable soil management is a major threat to soil biodiversity and the provision of soil-mediated ecosystem functions. Understanding the influence of agricultural land management practices on soil health and microbial communities is particularly important in arid and semiarid environments, where intensive agricultural practices cause a progressive decline in soil organic matter and overall agroecosystem resilience. In this context, the European project (H2020) SOILGUARD "Sustainable soil management to unleash soil biodiversity potential and increase environmental, economic and social wellbeing" aims to assess the influence of agricultural land management on soil quality and soil biodiversity, along different biogeographical regions of Europe. The Mediterranean semiarid region of Murcia (Spain), one of the most vulnerable to climate change, serves as an important case study to evaluate how agricultural practices shape soil functionality under increasing climate pressure. Specifically, this study investigates whether soil management practices, conventional (i.e., inorganic fertilization, intensive tillage) vs organic farming (minimum tillage, crop rotation, application of organic fertilizer), across a gradient of land degradation, significantly impact soil biodiversity.

Our results indicate that microbial richness is generally higher in soils under organic farming practices compared to soils under conventional management practices for most taxonomic groups, including bacteria, fungi, nematodes, and protists. This increased diversity in organic soils may be due to less invasive farming practices, such as reduced tillage and the use of organic fertilizers. In conventional farming, microbial richness remains consistently lower, with no significant differences observed across degradation gradients. However, with organic farming, microbial diversity decreases as degradation intensifies and reaches levels comparable to those in conventional soils. Conversely, when assessed the Shannon diversity index revealed a beneficial effect of organic management in highly degraded soils, maintaining community evenness despite a loss of richness. These results suggest that while organic farming practices are beneficial in maintaining microbial diversity, microbial communities richness may not be resilient in highly degraded soils. Beta diversity analyses reveal subtle differences in microbial community structure, although the clustering based on management practices is less pronounced than expected. However, soils under conventional management tend to show more homogeneity in microbial structure, while organic soils tend to show more variability, although these differences are not pronounced. Overall, our results illustrate the vulnerability of soils to degradation, regardless of management practices, and highlight the need for strategies to enhance soil resilience.

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GT 04 - 420 - P

EFFECT OF PASSIVE SOIL WARMING ON SOIL MICROBIAL COMMUNITIES AND THEIR FUNCTIONING ALONG AN ELEVATIONAL GRADIENT IN A TROPICAL FOREST

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil microorganisms are crucial for carbon and nutrient cycling and are sensitive to temperature. Tropical montane forests are key carbon sinks, yet our understanding of the impact of long-term warming on microbial functions, especially carbon use efficiency (CUE) remains limited. Integrating elevational gradients with translocation experiments can improve our understanding of soil–climate interactions in tropical regions. We hypothesized that increased microbial CUE will lead to higher carbon (C) losses from translocated soils due to increased microbial biomass leading to higher exoenzyme production.

To test this hypothesis, we translocated soil cores from two higher elevation sites (Vuria, ca. 2200 m a.s.l, and Ngangao, ca. 1800 m a.s.l) to a lower site (Macha, ca. 1500 m a.s.l) along a moist montane rain forest gradient in Taita Hills, Kenya, creating five treatments with 3 field replicate plots each: Macha native (M), Ngangao native (N), Ngangao translocated (Nt), Vuria native (V) and Vuria translocated (Vt). Following this field incubation for three years, we collected 75 soil cores in total (5 cores per field plot). From sieved and pooled (n=3 per treatment) soil samples we measured 18O-CUE at two different incubation temperatures (15°C and 25°C) and then let a set of samples to incubate for long-term (203 days) at those same incubation temperatures and continued to measure soil respiration rates. DNA sequencing of microbial community and a suite of soil physicochemical properties were measured, too.

Our results show that 18O-CUE didn't increase in translocated soils as hypothesized. At incubation temperature 15 °C, CUE slightly decreased in translocated soils without significance, but at 25 °C this decrease became larger and statistically significant, probably due to increased maintenance respiration. Microbial respiration was statistically significantly higher in the translocated soils compared to the native soils at both incubation temperatures. Enzyme activities increased in most translocated soils. No significant differences in total carbon (C) and nitrogen (N) contents were observed between the transferred (Nt and Vt) and native (N and V) soils even though there was a small decline in average C and N contents with warming. However, soil organic matter (SOM) quality changed significantly, with increased contributions of labile and decreased contributions of recalcitrant fractions to total SOM in the transferred soils, suggesting that warming facilitated the transformation of recalcitrant components into more decomposable forms. Overall, soil microbial activity and SOM quality are highly sensitive to translocation and temperature changes, with warming enhancing microbial processes and promoting the decomposition of recalcitrant C, which can in the longer-term lead to significant losses of SOC. We are currently looking at how changes in microbial community composition explain this improved capacity to decompose recalcitrant SOM.



GT 04 - 431 - P

EFFECT OF PASSIVE SOIL WARMING ON SOIL MICROBIAL COMMUNITIES AND THEIR FUNCTIONING ALONG A LATITUDINAL GRADIENT IN A BOREAL FOREST

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil microorganisms are crucial for carbon and nutrient cycling and are sensitive to temperature. Boreal forest soils store large amounts of organic carbon, but microbial responses to long-term warming in these systems remain unclear. Using latitudinal gradients and soil translocation helps clarify soil–climate interactions in cold regions. We hypothesized that increased microbial CUE under warming leads to enhanced soil organic carbon (SOC) loss in translocated soils.

Intact soil cores were collected from a boreal forest in Kivalo (66°21'N, 26°43'E) and passively translocated to a warmer site in Tammela (60°36'N, 23°50'E), creating three treatments: Kivalo native (K), translocated (KT), and Tammela native (T). After three years of field incubation, cores were sectioned into organic (O), eluviated mineral (E), and deeper mineral (B) horizons and sieved soils were incubated at 10°C and 20°C for six months under controlled conditions. Microbial respiration, soil physicochemical properties, and microbial biomass and community composition (via PLFA profiling) were all measured.

We are still waiting for the CUE results to be analysed based on D2O labelling of PLFA. So far, we have found warming altered microbial activity and carbon dynamics with horizon-specific patterns. Microbial respiration rate per unit soil weight was consistently lower in KT than in K soils at both temperatures, which indicates that increased decomposition had already decreased the labile SOC pool size during the 3 years of warming. In line with our first hypothesis, this coincided with statistically significant total carbon content loss in the O horizon (KT < K), indicating enhanced SOM decomposition under warming. However, the cumulative proportion of soil C respired in the KT group was slightly higher (though not statistically significant) than that in the K group in the O layer and B layer at 20ºC and in the O layer at 10ºC, which could indicate an on-going enhanced capacity of microbes to decompose recalcitrant C in the warmed soils. However, in deeper layers (E and B), differences in total soil carbon contents were smaller or reversed, suggesting potential microbial residue accumulation, or leaching of decomposition products from O layer downwards in the soil profile. Shifts in the proportional contributions of SOM fractions in the O horizon —reduced ethanol-extractable C and increased water- and acid-extractable C —support the idea that increased microbial processing, especially of the more recalcitrant compounds lead to their smaller molecular size decomposition products becoming extractable with water and acid. PLFA data revealed decreased microbial biomass in O layers and elevated fungal-to-bacterial ratios under warming, possibly reflecting community shifts driven by contrasting nutrient limitations between sites. These results underscore the complex, layer-specific impacts of passive warming on microbial processes and soil carbon stability in boreal forest soils.

GT 04 - 471 - P

DO ECOENZYMATIC STOICHIOMETRIC RATIOS REFLECT SOIL PHOSPHORUS DYNAMICS UNDER CONTRASTING MANAGEMENT SYSTEMS?

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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The ecoenzymatic stoichiometry [1], such as the activity ratios of β-1,4-glucosidase (βG), acid phosphatase (AcP), and alkaline phosphatase (AlP), offers a promising tool to assess microbial nutrient demand and soil phosphorus (P) availability. This study aimed to evaluate whether stoichiometric enzyme ratios (BG:AcP, BG:AlP, and BG:(AcP+AlP)) reflect differences in P dynamics under contrasting farming practices (organic vs. conventional) and soil types (calcareous vs. non-calcareous) across Mediterranean soils.

We analysed 47 soils with contrasting physicochemical characteristics from the Lisbon Wine Region. Although enzyme ratios followed normality within management × soil type subgroups (Shapiro-Wilk $p > 0.05$), the variability and uneven sample sizes led to the application of the non-parametric Kruskal-Wallis test. No statistically significant differences were found between management systems, soil types, or their interaction (all $p > 0.05$). Violin plots confirmed overlapping distributions, suggesting that microbial allocation to C and P acquisition is not directly driven by farming system or carbonate content alone.

To identify underlying drivers, a Redundancy Analysis (RDA) was performed using soil physicochemical variables. A forward selection retained a reduced model in which EPC_0 (equilibrium P concentration), SOC (soil organic carbon), and clay content together explained 33.6% of the total variance (adj $R^2 = 0.290$; global $p = 0.001$). All variables were individually significant: EPC_0 ($F = 7.98$, $p = 0.001$), SOC ($F = 9.10$, $p = 0.001$), and clay ($F = 4.69$, $p = 0.024$). These results indicate that microbial enzymatic strategies are primarily shaped by P availability and SOC, rather than management.

Agronomically, EPC_0, SOC, and ecoenzymatic ratios act as functional indicators of soil P status. High EPC_0 and high enzyme ratios suggest adequate P availability and lower enzymatic investment in P acquisition. In contrast, high SOC combined with low enzyme ratios reflects increased microbial effort to mobilize P, indicating a potential P limitation despite high organic matter. These patterns offer valuable insights for managing soil fertility and microbial functioning.

RDA ordination revealed that EPC_0 and SOC structured variation along RDA1 (24.9%), while RDA2 (8.4%) captured additional effects from texture and SOC. These gradients highlight the ecological and agronomic relevance of P availability and SOC as key regulators of microbial P strategies in Mediterranean soils. Enzyme ratios emerge as sensitive tools to evaluate soil P dynamics, even when soil management effects are not directly reflected in enzyme stoichiometric patterns.

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GT 04 - 477 - P

SOIL ORGANIC MATTER QUALITY INFLUENCES EARTHWORM ABUNDANCE IN WOOD PASTURES OF ROMANIA: HIGHER RECALCITRANCE AND LOWER ABUNDANCE UNDER TREE CROWNS

GT 04. SOIL BIOLOGY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Trees in temperate silvopastoral systems critically shape belowground biodiversity and soil properties; however, their influence remains poorly constrained. To this end, assessing differences in soil organic matter (SOM) content and quality between tree-influenced soils and open pastures is an essential step towards elucidating underlying biogeochemical mechanisms. Here, we examined the relationship between earthworm abundance and SOM content and composition along a gradient of tree influence in 30 oak-based wood pastures in Romania. Based on the expectation that there will be high inputs of oak leaf-litter and bark, we hypothesised that (i) soils near tree trunks would exhibit higher SOM content with greater proportions of recalcitrant compounds such as aromatic and alkyl carbon (C), compared to open pasture soils; (ii) increased presence of such nutrient-poor SOM would consequently decrease earthworm abundance. Sampling was performed at four discrete distances from oak trees of similar age, whereby earthworms and soils sampled at 1 and 3 m were under the tree crown, 7 m was at the edge of the crown, and 24 m was in the open pastureland. Earthworms were collected from the top 25 cm of the soil layer, and the soils were sampled incrementally at three depths down to 60 cm, all on south-facing slopes. Soil organic C (SOC) content was quantified by dry-combustion, while SOC composition was characterised using Fourier-transformed infrared (FTIR) spectroscopy, identifying specific C functional group peaks. We found higher SOC contents in the top soils (0-5 cm) located 1 m distant from tree trunks (64.2 g kg-1), coinciding with greater peak intensities for aromatic C in lignin, phenols, carboxylic acids, and aliphatic C, compared to soils at 24 m in open pastures (44.6 g kg-1). Conversely, polysaccharide-associated peak intensities showed the opposite trend, aligning with the highest earthworm abundance observed at the 24 m distance (208 ind m-2) than at the 1 m distance (128 ind m-2). A stronger positive relationship between SOC contents and aromatic C at 1 m distance ($p < 0.05$, $R2 = 0.82$) relative to 24 m ($p < 0.05$, $R2 = 0.51$) suggested the dominance of recalcitrant SOM near the trees. These findings support our hypothesis that elevated recalcitrant and aromatic SOM content near the tree trunk, which likely decreases the nutritional quality and palatability for earthworms, leads to their decreased abundance despite high SOM concentrations. In temperate silvopastoral systems, we have shown the distinct belowground biogeochemical processes under tree canopies compared to open pasture areas, which suggests differences in SOM stabilisation mechanisms.

KEYWORDS

FTIR, Soil organic carbon, earthworm, C functional groups, aromatic C, oak agroforestry, Transylvania

GT 04 - 491 - P

DEPLOYMENT OF A CITIZEN SCIENCE APPROACH TO STUDY EARTHWORM COMMUNITIES AT THE REGIONAL SCALE

GT 04. SOIL BIOLOGY / GT 16. CONNECTING PEOPLE AND SOILS

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Rising awareness of the importance of soil biodiversity conservation has led to an increasing demand from society (e.g. farmers, natural area managers, environmental consultants, urban planners) for tools to assess soil condition. Earthworms, as bioindicators, represent a valuable tool for evaluating the biological state of soils. However, current knowledge of earthworm communities in relation to land use and management remains insufficient to provide precise and robust diagnostics. To address this gap, the University of Rennes launched the collaborative platform EcoBioSoil in 2011. This platform provides an open-access tool to assess soil biological quality through earthworm communities, while also contributing to a growing database on these organisms. In 2015, with financial support from the French Office for Biodiversity, this collaborative tool was gradually deployed in the Île-de-France region (12,011 km², 1,017 inhabitants/km²). A four-step methodology was developed to engage a large number of non-expert participants in a given area (e.g. city, department, region) : (i) potential participant networks were contacted (e.g. local authorities, gardening and environmental associations, networks of natural area managers, agricultural organisations), (ii) volunteers were trained to apply a simplified version of the ISO 23611-1:2018 sampling protocol, (iii) participants sent the collected samples to the laboratory for species identification and (iv) results were systematically returned to participants, either in written form (with factsheets describing the biological parameters measured) or through discussions with experts. Between 2016 and 2024, this approach led to the sampling of 472 plots across 87 municipalities in Île-de-France, involving over 180 observers from 70 different organisations. Most participants came from local authorities (e.g. technical staff, biodiversity officers) and gardening associations, while private citizens, schools, and natural area managers were less represented. Sampling occurred mainly in urban environments (e.g. lawns, urban meadows, vegetable gardens), with fewer observations in agricultural areas (agroforestry, arable land, market gardening), and very few in natural habitats. In total, 51 species were recorded, with a mean abundance of 293 earthworms per square meter across all sampled plots. This presentation will provide further details on the collaborative project, including the sampling protocol, training tools, and key findings.



GT 04 - 500 - P

THE FUNCTIONAL AND GENETIC DIVERSITY OF SOIL FUNGI IN A LONG-TERM MINERAL AND ORGANIC FERTILIZATION FIELD EXPERIMENT

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Fungi play a crucial role in ecosystems, and their functions cannot be ensured by other species. Soil fungi can act as pathogens, decomposers, and symbionts, which interact beneficially with their host plants. Very few data are available on soil fungal communities in agroecosystems. However, there are limited data on soil fungal communities in agroecosystems. A long-term fertilization experiment established on chernozem soil near Martonvásár (Hungary) investigated the composition of both free-living and root-associated soil fungal communities. The study focused on plots from a maize-wheat rotation experiment, which had been treated for 60 years with different types of fertilizers: mineral (N, P, NPK), organic (manure), or a combination of both (Füzy et al. 2023). The soil samples were collected in 2022 from the rhizosphere of winter wheat at flowering phenophase. The fungal community's abundance and diversity were assessed using ITS-amplicon-based metagenomic analysis of the soil samples.

The results revealed that the quantitative parameters of soil-dwelling fungi increased in response to both organic and nitrogen fertilization.

Manure mainly influenced Ascomycota species, while nitrogen fertilization mostly affected Basidiomycota fungi.

Nitrogen fertilization, whether from simple, complex (NPK), or organic treatments, resulted in a decrease in fungal community diversity. The abundance of functional groups that promote plant growth was mainly driven by the presence of nitrogen fertilizer or organic manure. Fertilization drastically reduced the abundance and diversity of arbuscular mycorrhizal fungi in both the soils and plant roots, their presence becomes marginal under nutrient supply conditions optimal for the plant.

In agroecosystems, the levels of carbon (C), nitrogen (N), and phosphorus (P) are essential not only for the nutrient supply to cultivated plants but also for the composition and functionality of fungal communities that either plant growth support and inhibit, or organic matter degrade.

ACKNOWLEDGEMENTS

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GT 04 - 556 - P

EARTHWORM COMMUNITY DISTRIBUTION AT NATIONAL SCALE - FIRST RESULTS OF SOIL BIODIVERSITY MONITORING PROGRAM IN FRANCE

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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The monitoring program "RMQS-Biodiversity" (Réseau de Mesure de la Qualité des Sols –Biodiversité), started in 2021, aims to assess and monitor soil biodiversity (soil micro, meso and macrofauna and microflora) following a systematic grid (16 km * 16 km) covering all France, meaning huge diversity of soil types, climatical contexts and land use contexts. After 2 years of tests, in 2024, 69 sites were sampled across mainland France, including grasslands (18), field crops (22), forests (18) and some less-represented plots such as wasteland (5) and vineyards (2). The work presented here focuses on earthworms. Earthworms were sampled using a method combining manual sorting of a soil block (25 cm * 25 cm * 20 cm deep) and application of an extractant (mustard, 500 ml) (adapted from ISO standard 23611-1). At each site, 6 samples were taken. Earthworms are brought back to the laboratory, species determined and weighed. Communities were characterized by abundance (nb i.m-²), biomass (g.m-²), richness and diversity, and ecological categories (epigeic, endogeic, anecic).

A total of 5,557 earthworms were collected, representing an average of 215 individuals.m-², giving a biomass of half a tonne per hectare and an average of 5.5 species per plot. Preliminary results confirm the significant impact of land use on earthworm communities, in terms of abundance, biomass and species composition: grasslands appear to be the most favorable habitats (average abundance 382 individuals.m-², average biomass estimated at one tonne per hectare and average species richness of 7. 2 species), in contrast to field crops (mean abundance 196 individuals.m-², mean biomass 342 kg per hectare and mean species richness 4.5 species), with forests presenting the least favorable habitat (mean abundance 132 individuals/m², mean biomass 260 kg per hectare and mean species richness 5.8 species). An analysis of community composition reveals considerable disparities: some earthworm species are very common, such as Allolobophora chlorotica (41/69 sites), Aporrectodea caliginosa (36/69 sites) and Aporrectodea rosea (30/69 sites), while others were observed only once at all 69 sites (e.g. Lumbricus bouchei, Prosellodrilus amplisetosus, Aporrectodea jassyensis). Despite the fact that land uses strongly influence earthworm community, this study also highlights the influence of soil-climate contexts and geographical location in earthworm community structure and allows the species distribution mapping at national scale.

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GT 04 - 612 - P

AN EXTRACELLULAR EDNA APPROACH TO EVALUATE TILLAGE EFFECTS ON SOIL BIODIVERSITY ACROSS FUNCTIONAL GROUPS

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Soil biota drive many of the essential soil functions that underpin soil-based ecosystem services that are indispensable for sustainable agriculture. The assessment of soil biodiversity is therefore crucial to understand the effects of agricultural management practices, such as tillage, on biological soil health. Molecular techniques such as environmental DNA (eDNA) metabarcoding are widely used to study soil biodiversity and have proven effective for microbial soil organisms. To extend their potential to soil fauna, methodological adaptations are needed, particularly to accommodate the larger body sizes and different eDNA distribution patterns associated with faunal organisms. In this study, we use eDNA metabarcoding based on the extraction of extracellular DNA (exDNA) from larger volumes of soil to enable the simultaneous assessment of soil microbial and faunal diversity. We apply this exDNA approach to assess the functional diversity of belowground communities in agricultural soils subjected to different tillage intensities. Employing an integrated metagenomic and metabarcoding approach, we target multiple groups of organisms – bacteria, fungi, nematodes, annelids, and arthropods – that occupy vital roles within the soil ecosystem. Faunal taxa will be assigned to functional categories, such as trophic roles and earthworm ecological strategies, and will be used to derive bioindicators, including nematode-based indices, for assessing soil health. Similarly, microbial community analysis will target key functional groups including symbionts, pathogens, and saprotrophs as well as genes associated with nutrient cycling, organic matter decomposition and other soil functions. This research will advance our understanding of tillage impacts on functional soil biodiversity. Thereby it will support the development of integrated biotic soil health assessment tools to guide farmers, researchers, and advisors in evaluating sustainable soil management practices.

GT 04 - 618 - P

LIMNO-TERRESTRIAL ROTIFERS IN THE NORTHERN HEMISPHERE MAY NOT EXHIBIT DIVERSITY GRADIENT BY LATITUDE OR ALTITUDE

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Microscopic invertebrates are a vital component of terrestrial ecosystems, playing a key role in the biogeochemical cycling and trophic interactions in soil and associated vegetation. Limno-terrestrial rotifers (Rotifera) are one of the most common groups of soil microfauna with a global distribution spanning from the equator to the polar zones. Recent studies suggest that their diversity is substantially underestimated (Iakovenko et al., 2015), the presumed cosmopolitanism is limited at least to the level of continents, and diversity patterns vary on a local scale (Fontaneto et al., 2008, 2015). The latitudinal diversity gradient (LDG), one of the central concepts in biogeography, predicts a gradual decline in species richness from the tropics toward the poles, presumably in correspondence with the gradients in nutrient availability, climatic variables, and associated speciation speed. However, increasing evidence in scientific literature points to organismal groups in which LDG differs from that assumption.

This analysis is the first one on the global LDG in limno-terrestrial rotifers and is based on calculating conventional diversity metrics (α-diversity, or number of species per sample, and γ-diversity, or total number of species within a defined area). The dataset included records of morphologically identified species from 1,549 samples collected at latitudes from N 2.0615 º to N 79.8105 º and altitudes from 0 to 4,610 m.

Both species richness and density of rotifers across the sampled gradient had their maximum between N 50º and N 60º, slightly decreasing toward the North Pole and equator (Fig. 1A, α-diversity; 1B, γ-diversity). However, statistical analyses (GAM with number of species per sample or 1º latitude bin as response variable and latitude and altitude as explanatory variables) did not confirm the presence of the latitudinal or altitudinal gradient. In the best-fit model (est.±se: 9.75±0.8 for α-diversity, 4.92±0.63 for γ-diversity, $p < 0.0001$), diversity was explained by density, and for γ-diversity also by the number of sampled habitats per area. Further study is needed to evaluate whether rotifer density in this case is indicative of habitat type, or if it reflects research effort (a higher chance to encounter rare species in samples with a higher number of individuals).

ACKNOWLEDGEMENTS

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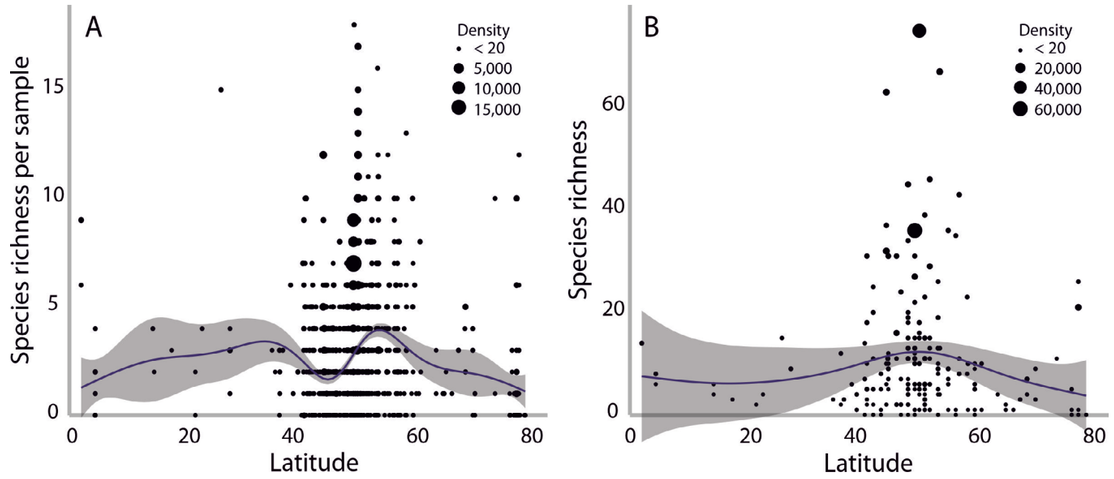
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GT 04 - 649 - P

COVER CROPS AS WEED CONTROL PRACTICE IN HORTICULTURE: A CASE STUDY IN PORTUGAL.

GT 04. SOIL BIOLOGY / GT 04. SOIL BIOLOGY

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Cover crops are considered a sustainable practice in agroecosystems, offering various benefits such as enhancing soil biodiversity and increasing the release of root exudates. These exudates can suppress weed growth by reducing competition with crops for space, light, water and nutrients. Additional advantages include improved crop yields, enhanced nutrient recycling can contribute to reduced input requirements. Several studies suggest that cover crops may be an effective strategy for managing glyphosate-resistant weed species.

In Portugal, some of the most problematic weed species include Cyperus rotundus, Solanum nigrum and Datura stramonium. Their impact is due to acquired herbicide resistance in C. rotundus, as well as the seed production and close botanical characteristics of S. nigrum and D. stramonium to the crops. This weeds also represents a risk to food chain, due to their toxicity and food security related to the presence of harmful substances

This study aimed to evaluate the influence of cover crops, on weed development and abundance. This study was conducted in two horticultural fields, where cover crops were installed, prior to the main crops: a) tomato, and b) succession of pumpkin / pepper / broccoli located in the Ribatejo and Oeste regions of Portugal, respectively.

For each sampling period, weed abundance and phenological stage indexes were registered and compared with those from the control plots. The data was analysed using independent samples t-tests.

The results indicate a trend toward phenological delay ($p = 0.126$), and a reduction in the abundance of weeds ($p = 0.012$), in the cover crop plots, compared to the control., This findings suggest a beneficial effect of the cover crops on natural weed suppression. Cyperus rotundus was the most affected species in terms of reduction abundance.

KEYWORDS

IPM, Weed supression; Solanum nigrum; Datura stramonium; Cyperus rotundus.



GT 04 - 667 - P

EFFECTS ON SOIL MICROORGANISM FUNCTIONALITY FROM THE USE OF DIFFERENT TYPES OF MANURE IN RAINFEED FIELD ORGANIC CROPS

GT 04. SOIL BIOLOGY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil microorganisms play an essential role in the nutrition of crops, especially when organic fertilizers are used, as they are responsible of breaking down organic matter into plant-available nutrients such as nitrate or phosphate. Due to their key role, understanding how different organic fertilizers may affect the soil microbiota can help understanding differences in nutrient use efficiency.

A field experiment was carried out during six years. Five treatments were established: a control with no fertilization and four treatments with the application of different organic fertilizers (compost, chicken manure, cattle manure and pig manure) at the same nitrogen rate (170 kg N ha-1 yr-1). The rotation established in the trial was maize, pea and wheat, with manure application before maize and wheat sowing. After 6 years of the start of the experiment, the topsoil (0-0.2 m) was sampled and the soil microorganisms were extracted and incubated using Biolog Ecoplates™, that have incubation wells for 31 different carbon substrates. The absorbances of each well were recorded every 24 hours for 96 hours in total and used to determine the soil microorganism's capacity to degrade each carbon substrate.

After 24 hours of incubation, soil microbiota in the chicken manure treatment degraded a larger diversity of groups of compounds, including carbohydrates, carboxylic and acetic acids, amines/amides and polymers, while the cattle manure one degraded only carbohydrates (Figure 1).

From 48 hours of incubation and onwards, soil microbiota from all fertilization treatments degraded all classes of compounds. After 96 hours, the degradation in the control and pig manure treatment was lower when compared to the rest of them.

The microbiota established in the soil with recurrent organic fertilization regimes may have had a greater adaptation and predisposition, in the short term, to using complex organic compounds, which can't be observed in the control and pig manure treatments. The greater degradation of amino acids in the chicken manure treatment also stands out. On the other hand, microorganisms in soil amended with cattle manure and chicken manure are those that quickly degrade most compounds, especially carbohydrates and carboxylic/acetic acids, which are the simplest and easily degradable compounds.

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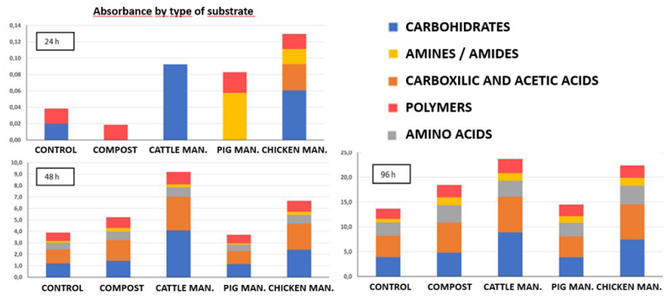


Figure 1. Cumulative absorbance (unitless) measured in the different substrates of the Biolog Ecoplates™ for different organic fertilization treatments.

GT 04 - 689 - P

IMPACTS OF CANOPY DISTURBANCES IN AN OAK FOREST ON SOIL BIODIVERSITY INCREASE WITH ORGANISM SIZE

GT 04. SOIL BIOLOGY / GT 04. SOIL BIOLOGY

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Soil biodiversity is essential for forest ecosystem functioning as it plays a key role in litter decomposition, nutrient recycling and soil carbon sequestration. Since forest disturbances can have major impacts on soil biodiversity and associated ecosystem services, there is an urgent need to provide evidence on the ecological responses of soil biodiversity to forest disturbances. To this end, we established an experimental site to study the impacts of disturbance on soil biodiversity and properties resulting from tree-felling interventions of different intensity and post-disturbance treatments (adding slash to the soil or not) in a Quercus faginea Lam. forest located in the northern Spain. The experimental design consisted in a randomized block design that included five treatments: control, 50% canopy disturbance with and without slash, 100 % canopy disturbance with and without slash. Comprehensive inventories of soil biodiversity of microbes, microfauna, mesofauna and macrofauna were carried out after one, nine and 21 months following the disturbance. Our results showed how body size determined the response of the soil community to canopy disturbance intensity and time since disturbance. The effects of the disturbance were more severe as the size of the organisms increased and as the disturbance intensity increased. We conclude that while forest show certain capacity to absorb disturbance, assisting soils with slash addition after disturbances help maintaining habitats and the soil microclimatic conditions to conserve abundances and diversity of organisms and functions. Moreover, organism body size emerges as a potential integrative functional trait indicative of responses to disturbance.

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GT 04 - 717 - P

FROM FARM TO MICROBE: ORGANIC AMENDMENTS AND SOIL TEXTURE AS DRIVERS OF SOIL MICROBIOME COMPOSITION

GT 04. SOIL BIOLOGY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Understanding how agricultural practices affect soil bacterial communities is vital to mitigating the negative impacts of intensive agriculture on soil health and preventing further deterioration of arable land. This study investigates the interaction between organic amendments and soil texture in agricultural soils (n=93) used for arable production, using a 16S rRNA-sequencing based microbial community analysis. Amendments include slurry, digestate, and farmyard manure. Additionally, soil physicochemical parameters were collected to explore the drivers of patterns of soil microbial diversity. We applied a dynamic core microbiome inference strategy [1], coupled with neutral modelling to unravel deterministic pressures on core communities in the presence of the amendments. Regression modelling including LASSO-type [2], and generalised linear latent variable modelling [3] were incorporated with agricultural practices as covariates to find differential OTUs. Amendments significantly influenced microbial community composition, leading to distinct variations in microbial community structure. Soil texture was also found to affect bacterial community composition, exerting selective pressure. Additional covariates such as calcium levels, the crop grown one year previously, loss on ignition (LOI), and farm ID were also found to be significant factors affecting community structure. Candidatus Nitrosotalea was found to be positively associated with the application of farmyard manure, whereas genus AD3 of phyla Chloroflexi was found to be negatively associated with application of digestate and slurry. The results highlight the importance of considering multiple factors when trying to establish how agricultural practice affects soil microbial communities.

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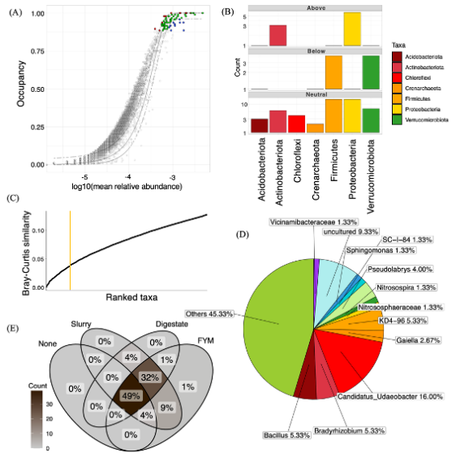


Figure 6. Core microbiome identified through a dynamic approach is represented by species occupancy abundance diagrams incorporating a site-specific occupancy criterion for a soil amendment occupancy model. (A) Points above the model are selected for by the environment and shown in red, points below the model are dispersal limited and shown in blue. The neutral core is shown in green colour. (B) Barplot representing the count of the number of OTUs fitted with the neutral model (Neutral; driven by stochastic processes), above the neutral model (Above; selected by the environment), and below the neutral model (Below; selected by dispersal limitation). (C) Ranked OTUs in terms of the Bray-Curtis contribution of OTUs. OTUs are added iteratively until the addition of one or more OTUs offers diminishing returns on the explanatory value of beta diversity. This threshold is represented by the vertical yellow line. (D) Core microbiome phylum composition for the occupancy model. (E) Venn diagram showing the overlap between 100% prevalent core OTUs (i.e. those OTUs observed in all samples) between different amendment types.

GT 04 - 730 - P

BEYOND THE ACTIVE INGREDIENT – THE ROLE OF ADJUVANTS IN MODULATING THE RESPONSE OF SOIL METHANOTROPHY TO GLYPHOSATE

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Due to the progressing intensification of agriculture, the amount and frequency of use of plant protection products is increasing significantly. This also applies to herbicides, in which the active ingredient is glyphosate. This compound is the most widely used herbicide in the world, and its expected annual consumption estimate at 9.2 x 108 kg by 2025 (1). Commercial products, in addition to the active ingredient, also contain adjuvants, whose role is to enhance and protect the toxic properties of active substance (2). Despite mass application, the impact of adjuvants on the microbiota, including methanotrophic bacteria, remains poorly understood. In this study, differences in the effects of commercial glyphosate-based solutions (GFC) and the pure active ingredient (GFP) on methanotrophic bacteria are presented. The methanotrophic activity (gas chromatography), methanotrophic community composition (16S rRNA gene amplicon sequencing) and abundance (pmoA-based dPCR) in agricultural soils, representing Gleysol, Fluvisol, and Leptosol, were analysed.

Generally the response of soil low affinity methanotrophic activity (MT-L) to glyphosate formulations consists of two phases: stimulation under sub- and label dose conditions followed by decline in the moderate and heavy overdose conditions. The threshold differentiating these phases, however depend on soil properties and glyphosate formulation used. In experiments carried with the use of GFP, the concentration threshold, which resulted in statistically significant MT-L decrease was higher in all the soils studied, indicating a negative effect of adjuvants on methanotrophic bacteria. Both glyphosate formulations increase microbial quantity in all soils, yet the effect is stronger under exposure to the GFC formulation implying that adjuvants are also utilized as substrates. Soil exposure to GFC formulation increased methanotroph numbers to a greater extent than treatment with GFP. This may be explained by the fact that biodegradation of both glyphosate and adjuvants may lead to formation of simple compounds, accessible to facultative methanotrophs.

ACKNOWLEDGEMENTS

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GT 04 - 744 - P

SOIL PROKARYOTIC COMMUNITY RESPONSES AFTER INCORPORATION OF A N- AND P-ENRICHED POLYSACCHARIDE-BASED BIODEGRADABLE MULCHING: A MESOCOSMS ASSESSMENT

GT 04. SOIL BIOLOGY / GT 02. SOIL PHYSICAL CHEMISTRY

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The widespread use of plastic mulching films is a major source of soil macro (> 5mm) and microplastics (MPs) (100 µm < MPs < 5 mm) in agricultural fields due to their repeated use, low recycling rates, and susceptibility to fragmentation. MPs influence soil functions, as well as physical and chemical properties, while also impacting on biodiversity. Use of biodegradable mulching films has emerged as a sustainable alternative to conventional non-biodegradable plastics for their full degradation in soil after the life service expired, thus markedly reducing their environmental impact. Burying biodegradable mulching films affects microbial communities, and the C-substrates entering the soil can stimulate functional prokaryotic groups which outcompete others for available resources, potentially altering the balance of soil microbiome.

Aim of this work was to assess the influence of polysaccharide-based biodegradable mulching films, either enriched or not with an inorganic N and P source (NH4H2PO4, MAP), on prokaryotic soil communities. Four mulching treatments were compared across three consecutive mulching events during a 8-month period using outdoor mesocosms: two innovative biopolymers constituted by sodiumcarboxymethyl cellulose (CMC) and chitosan/sodium alginate (CS/SA), enriched (IBMF+NP) or not (IBMF) with a 25% MAP; a commercial starch-based biodegradable film (Mater-Bi® grade EF04P); and a traditional non-biodegradable polyethylene film (LDPE). Observed variables were: chemical and biochemical soil parameters (Corg, Nt, MBC, MBN, Rbas) and prokaryotic community changes by using 16S rRNA gene sequencing of soil-extracted DNA.

Results showed that biodegradable treatments, particularly IBMF+NP, better preserved microbial C and N pools compared to PE, which exhibited the greatest C losses, as corroborated by the Rbas that increased consistently in PE-treatment, probably reflecting a greater microbial stress and increased C mineralization. Despite a declining trend in MBC and MBN, reduced loss were found in IBMF-treated soils. The alpha diversity metrics (Shannon, Faith) at phylum level was similar among treatments, thus suggesting a prokaryotic community resilience to mulching type. However, the treatment with biodegradable film with a source of N and P promoted specific groups involved in nutrient cycling, such as Bacillus, Rhizobia, Devosia, Sphingopyxis, and Alcaligenaceae. Conversely, the PE treatment was associated with genera like Steroidobacter, Chryseolinea, and Ramlibacter, some of which are linked to contaminant degradation or microbial stress.

In brief, biodegradable mulching films, especially when N- and P-enriched, did not markedly alter the prokaryotic soil community structure, at least at high taxonomic level, but stimulated specific prokaryotic groups. These findings encourage the use of CMC_CS/SA biodegradable films as a sustainable alternative to conventional mulches to promote soil health and reduce environmental impact.

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GT 04 - 759 - P

DOES SOIL MOISTURE CONTENT RESHAPE THE MICROBIAL COMMUNITY DYNAMICS IN COWPEA RHIZOSPHERE?

GT 04. SOIL BIOLOGY / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Cowpea (Vigna unguiculata) is a dryland subsistence crop widely cultivated in tropical and subtropical regions for its contributions to food security and soil fertility. Nevertheless, cowpea productivity is strongly affected by hydric stress, which is being exacerbated by climate change, posing a major threat to its yield potential. This study assessed the influence of soil moisture content on the diversity and composition of microbial communities in cowpea rhizosphere soils collected from three fields in the Trás-os-Montes region (Northeast Portugal), characterized by low (2.4% w/w), moderate (3.9% w/w), and high (10.5% w/w) water content. A culture-independent metabarcoding approach targeting the 16S rRNA (V3–V4) and ITS2 regions in bacteria and fungi, respectively, was used, followed by bioinformatics processing and statistical analysis. Bacterial and fungal diversity indices revealed no statistically significant differences across fields. Nonetheless, bacterial communities exhibited higher overall diversity, richness, and evenness compared to fungi. Non-metric multidimensional scaling and PERMANOVA revealed distinct microbial community compositions between fields, explaining 38.0% and 30.1% of the variation in bacterial and fungal communities, respectively ($p = 0.001$ for both). Fields with moderate and high-water content were dominated by the bacterial classes Actinobacteria, Alphaproteobacteria, and Gammaproteobacteria, along with fungal classes Agaricomycetes, Ustilaginomycetes, and Tremellomycetes. In contrast, low-moisture fields were enriched in bacterial classes Bacilli and Acidobacteriae, and fungal classes Dothideomycetes, Eurotiomycetes, and Agaricomycetes.

These findings highlight the role of soil moisture in shaping rhizosphere microbial assembly and may inform microbiome-based strategies to enhance cowpea resilience under drought-prone conditions.

KEYWORDS

Vigna unguiculata, Drought, Hydric stress, Climate change, Microorganisms.

ACKNOWLEDGEMENTS

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GT 04 - 766 - P

THE EFFECTS OF IVERMECTIN ON A COMMUNITY OF TERRESTRIAL NEMATODES

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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It has been known for long that nematodes are not only present in soils in outstanding numbers, but they also play an important role in any major ecological processes including herbivory, bacterial and fungal feeding as well as predatory and omnivory. Due to these, their communities offer several ecosystem services including various opportunities for applications in biological indication of contaminant effects. On the other hand, ivermectin (IVM), the active ingredient in some of the most widely used veterinary antiparasitic drugs, is released to aquatic and terrestrial habitats in considerable amounts globally. However, its impacts on free-living nematodes as non-target organisms have not yet been clarified to a satisfactory extent. Therefore, we found it relevant to perform a pilot study to reveal IVM effects on nematode community-based indicator parameters.

Approximately 2 kg of a bulk soil sample was taken on 13.03.2025. from the lawn in the park in front of the main building of Szent István Campus of Hungarian University of Agricultural and Life Sciences (MATE) in Gödöllő, Hungary. This location has earlier been found to host a soil nematode community with a relatively high proportion of stress-sensitive nematode taxa. This native soil was placed into plastic experimental boxes without any pre-treatment as drying or defaunation and treated as follows: a negative control with water addition only, a positive control (DMSO added) and IVM in concetrations of 100 µg/l and 1000 µg/l, respectively. Samples were incubated for 5 days at 20 ºC then extracted with Baermann-funnels. So far, only the abundance of nematodes extracted from the samples have been obtained while community-based nematological index values are to be finalised yet.

Based on one way ANOVA followed by Tukey post hoc test, total nematode numbers in control and DMSO treatment did not differ, while these values significantly decreased in both concentrations of the IVM treatment. ANOVA F value was 17.41 and treatment effects were between 0 - 0.001. So, nematode abundance as a less sensitive parameter shows already a remarkable effect of IVM addition, even in the treatment of lower concentration. This underlines the importance of further and more detailed studies to explore ivermectin effects on free-living soil nematodes.

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GT 04 - 777 - P

GENETIC AND SOIL INFLUENCES ON THE GRAPEVINE RHIZOSPHERE MICROBIOME

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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In vineyard cropping systems, the rhizosphere microbiome arises through recruitment and filtering of the bulk soil microbiome shaped over time by soil carbon and nitrogen, climate, pH and historical legacies of vineyard management. The recruitment and filtering steps occur under the genetic influences of rootstock and scion that together drive variability in rhizosphere microbiome diversity and composition.

This study compares rhizosphere microbiomes of four Pinot Noir blocks under two rootstocks (101-14 and 420A) and four scions (777, 828, Calera, Mt. Eden). Core microbiomes were consistent across all replicates. The most abundant bacterial phyla were Actinobacteriota, Proteobacteria, and Acidobacteriota (respective relative abundances = 27.14%, 24.71%, 8.73%); and the most abundant fungal phyla were Ascomycota, Basidiomycota, and Mortierellomycota (respective relative abundances = 45.40%, 29.92%, and 6.44%).

Alpha diversity was best expressed in bacterial data with Faith's Phylogenetic Diversity (PD) and Shannon index. Rootstocks 101-14 and 420A were most significantly different in bacterial Faith's PD (p-value = 0.037373). Marginally significant differences (p-values = 0.049535) in bacterial diversity were found between rootstock x scion pairs 420A x 777, 101-14 x 828, and 101-14 x Calera. Fungal microbiome differences were better captured in beta diversity assessed using Principal Coordinate Analysis (PCoA) and three dissimilarity indices: Bray—Curtis, Weighted UniFrac, and Unweighted UniFrac.

Significant differences in taxonomic abundance were identified at the phylum, class, and order levels. Rootstock 420A accumulated more plant growth promoting (PGP) taxa, including the bacterial orders Azospirillales 507929, Bacillales B 306089, and Nitrospirales; and the arbuscular mycorrhizal fungi (AMF) order Entrophosporales. Rootstock x scion pair 101-14 x 828 had a higher abundance of the fungal order Dothideomycetes, order Incertae Sedis, which is positively correlated to soil organic carbon (SOC) content.

Additional research would confirm the presence of specific beneficial microbes across several years of data, so information could be used to make replanting decisions that maximize microbial benefits. Future research would use metagenomics and metabolomics to better understand microbiome composition and functionality, and develop inoculants that mimic the natural rhizosphere microbiome, providing more successful inoculation and effective delivery of ecosystem services like C sequestration, PGP, biocontrol of pathogens, and nutrient cycling.

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GT 04 - 890 - P

THE USE OF FILTER PAPER METHOD FOR CAPTURING THE EJECTED MATERIAL DURING SOIL SPLASH PHENOMENON IN CONTEXT OF BACTERIAL DNA ISOLATION

GT 04. SOIL BIOLOGY / GT 05. SOIL HYDROLOGY & EROSION

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The soil splash phenomenon, caused by the impact of falling raindrops on soil surfaces, is an initial stage of water erosion, during which soil particles could be detached and ejected over different distances. This rapid physical process not only affects soil structure and surface properties, but could also plays a role in the passive movement and redistribution of soil microbial populations across the soil surface and potentially into adjacent ecosystems.

The aim of this study was to evaluate the applicability of the filter paper method for capturing the ejected material during soil splash for the purpose of bacterial DNA isolation. In controlled laboratory conditions, single water drops were released on pre-saturated soil samples, while the ejected material was collected on sterile filter paper surfaces positioned around the drop impact zone. Next, DNA extraction from the collected material was carried out using the commercial Qiagen DNeasy PowerMax Soil Kit according to established protocols. Due to the limited amount of biomass obtained, extracted DNA concentrations remained below fluorometric detection thresholds, and to achieve sufficient template amounts for further PCR amplification, additional concentration steps were required.

The results demonstrate that filter paper collection could be a feasible approach for capturing

splash-ejected material for microbiological studies, though challenges remain in DNA yield and detection sensitivity. This method provides a foundation for further investigations into microbial transport via soil splash processes.

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GT 04 - 917 - P

BELOWGROUND NUTRIENT TRANSFER BETWEEN SCOTS PINE AND BILBERRY MEDIATED BY MYCORRHIZAL FUNGI

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Ectomycorrhizal fungi (EMF) and ericoid mycorrhizal fungi (ERM) are essential for plant-soil nutrient cycling in forest ecosystems, forming symbiotic relationships with plant roots. They receive 10-30% host plant photosynthate and in return improve plant nutrient acquisition. EMF symbiosis can establish common mycorrhizal networks (CMNs), connecting multiple plant hosts from the same or different species. CMNs have been found to enhance plant productivity and crucial in carbon sequestration. However, the quantity of the resources exchanged between plants, the role of ERM and who manipulates the exchanges remain unanswered. Therefore, it's significant to investigate CMNs role in belowground nutrient cycling and how it relates to the host species identity.

This study aims to assess 1) the significance of carbon and nitrogen transfer through CMNs between pine and bilberry, 2) whether the interaction of different plant species affect their growth performance. One-year-old seedlings of Scots pine (Pinus sylvestris L.) and bilberry (Vaccinium myrtillus) were planted in the custom-made pots, which were divided equally with three types of barriers: solid barrier (no connection), 50µm mesh (roots blocked) and no-barrier (full connection). The seedlings were planted from October 2023 to October 2024 in three combinations: pine-bilberry, pine-pine, bilberry-bilberry. Labelling with 13CO2 and 15N-needle-litter were performed for tracing the nutrient cycling. To quantify the carbon transferred by fungal hyphae, soil microbial biomass total C and 13C were measured, alongside the plant photosynthesis and 13C in needles/leaves. Plant productivity was evaluated through shoot and roots biomass. Microbial carbon use efficiency was analyzed using 18O-H2O to determine SOC stabilization.

Preliminary results will be presented in the poster.



GT 04 - 928 - P

IMPROVING SOIL ORGANIC MATTER AND BIOLOGICAL ACTIVITY IN CITRUS ORCHARDS UNDER MEDITERRANEAN CONDITIONS

GT 04. SOIL BIOLOGY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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In Spain, citrus production is concentrated in the Mediteterranean region, where challenging conditions, such as high temperatures, irregular rainfall, low organic matter, and excessive use of mineral fertilizers, have led to poor soil quality. These degraded soils suffer from structural issues, low water retention, erosion, contamination, and nutrient imbalances, all of which hinder plant growth and ecosystem functioning. Among the key factors influencing soil quality, organic matter content and biological activity are particularly critical, both being strongly affected by cultural practices. In recent years, the Soil Fertility and Plant Nutrition team at CDAS has evaluated the impact of various soil management techniques on these parameters in citrus cultivation, within the framework of different research projects. This study presents the main results from field trials involving i) the use of green covers, ii) straw mulching and compost amendments, and iii) the application of microbial biostimulants. In all experiments, soil organic matter and indicators of living soil microorganisms: C biomass (as measure of quantity) and dehydrogenase activity (as a measure of activity), were determined. Enzyme activities as β-glucosidase and alkaline phosphatase, that serve as indicators of soil functioning, were also analyzed. In experiment i), citrus soils with spontaneous and cultivated green covers were compared to bare soils across eight locations of Italy, France, Portugal and Spain. Results showed that soil quality was significantly improved by maintaining vegetative covers compared to uncovered soils. However, no consistent differences were found between spontaneous and cultivated covers. Outcomes were strongly influenced by different factors such soil type, cultivated cover species or the duration since cover establishment. In experiment ii), rice straw mulching and rice straw-sewage sludge compost, applied individually and in combination, were compared with untreated soil, in commercial orchards of 'Clemenules' and 'Navelina'. Compost amendments, with or without straw mulching, increased organic matter concentration compared to the control. Regarding the biological parameters, C biomass was lower in soils receiving both mulching and compost. No significant changes were found in dehydrogenase activity. In experiment iii), conducted in commercial plots of 'Oronules', trees receiving 100 % of NPK mineral fertilization, were compared to trees receiving 70% or 50% but supplied with microbial biostimulants based on mycorrhizal fungi and rhizosphere bacteria. While soil organic matter levels remained unchanged, improvement in biological parameters were observed in soil inoculated with the microbial consortium, regardless of whether the NPK units were reduced to 70 or 50%. This study highlights that green covers, compost-based amendments, and microbial biostimulants can enhance soil quality in Mediterranean citrus orchards, offering promising strategies to maintain healthy soils under challenging environmental conditions.

GT 04 - 943 - P

FROM ATLANTIC FOREST TO AGRICULTURE: SHIFTS IN SOIL BACTERIAL DIVERSITY AND COMPOSITION FOLLOWING COFFEE PLANTATION EXPANSION IN BRAZIL

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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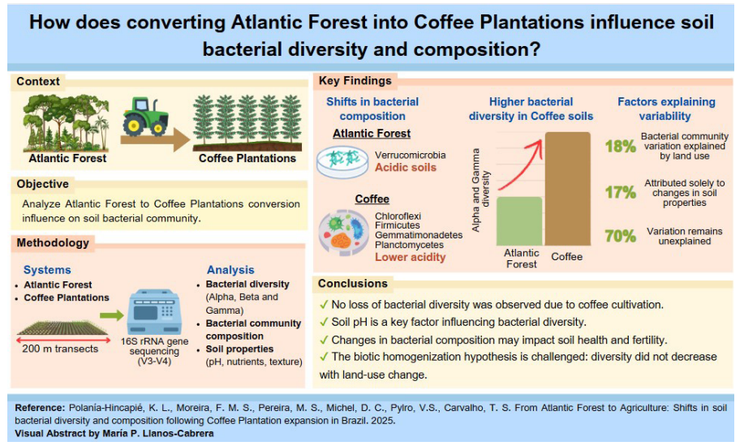
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In Brazil, the Atlantic Forest is one of the biomes most impacted by anthropogenic activities, with coffee cultivation as a major driver of land use change. However, the effects of converting native forest into agriculture on soil bacterial communities remain poorly understood. This study evaluated how converting natural Atlantic Forest to coffee plantations affects soil bacterial diversity and composition. Soil samples were collected along 200 m transects in both land uses and analyzed using 16S SSU rRNA gene (V3–V4 region) sequencing. Sequences were clustered into operational taxonomic units (OTUs) at 97% similarity. Results showed that coffee cultivation increased alpha diversity (Hill's numbers q = 0, q = 1, and Faith's Phylogenetic Diversity) and gamma diversity (q = 0 and q = 1), closely associated with higher soil pH due to liming. Soil acidity and nutrient availability were key drivers of bacterial community structure. Atlantic Forest showed distinct bacterial composition, associated with higher acidity, Al saturation, and Fe content. In contrast, coffee plantation soils were linked to higher fertility attributes, such as increased pH and elevated levels of Ca, Mg, K, and P. A natural fertility gradient in Forest also influenced bacterial composition. Variation partitioning analysis revealed that land use explained 18% of the variation in bacterial community structure, with 8% due to soil condition changes and 12% related solely to soil attributes, leaving 70% unexplained. Bacterial phyla such as Chloroflexi, Firmicutes, Gemmatimonadetes, and Planctomycetes were more abundant in coffee plantations, favored by reduced acidity. Verrucomicrobia dominated in the more acidic forest soils. The Proteobacteria to Acidobacteria ratio was higher in coffee soils, suggesting a shift toward copiotrophic bacteria, potentially due to greater availability of labile organic substrates. Overall, coffee cultivation did not reduce soil bacterial diversity but significantly altered community composition, largely due to changes in soil acidity. These findings highlight that shifts in microbial communities are not necessarily accompanied by biodiversity loss and are strongly influenced by land management practices.

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Visual abstract of research From Atlantic Forest to Agriculture:
Shifts in soil bacterial diversity and composition following Coffee Plantation expansion in Brazil



GT 04 - 949 - P

PREDICTIVE POTENTIAL OF SOIL MOLECULAR MARKERS UNDER CONTRASTING GROUNDCOVERS MANAGEMENT IN VINEYARDS AND OLIVE GROVES

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Cover crops represent a key agroecological strategy to improve soil health and the sustainability of agricultural systems, particularly in Mediterranean regions where erosion, loss of organic matter, and extreme climatic events are becoming increasingly frequent. These crops help improve soil structure, increase water retention capacity, and stimulate biological activity by promoting more diverse and functional microbial communities. However, soil microbial responses to cover cropping may vary depending on crop type, soil characteristics, and agronomic management.

Within this context, and as part of the SANCHOSTHIRST European project, we aimed to evaluate the usefulness of specific microbial molecular markers as predictive indicators of the effects of soil management (cover cropping vs. tillage) on microbial functionality in vineyards and olive groves under Mediterranean climate conditions. The study was conducted on 15 commercial farms distributed across different wine- and olive-producing regions of Spain (10 vineyards and 5 olive groves). On each farm, two plots with contrasting management practices (with and without cover crops) were selected, and soil samples were collected at two depths (10 and 30 cm), yielding a total of 180 samples.

From the DNA extracted from each sample, six functional molecular markers were quantified using quantitative PCR (qPCR): AOA and AOB (ammonia-oxidizing archaea and bacteria); ureC (associated with urease activity); BGH3 and FGH3 (bacteria and fungi involved in β-glucosidase activity); and phoD (bacteria with phosphatase activity). The effects of management and sampling depth were evaluated through analysis of variance (ANOVA), conducted separately for each farm and crop type.

The results allowed the classification of the farms into four groups based on the molecular marker responses. Group 1, consisting of vineyards (ARAN, FAR, ENCIN, ROB), showed significant effects of management on all markers, with higher abundances in cover cropped plots. In Group 2 (OCHOA, VERO, FUEN, ALMA, GALVE), which included both vineyards and olive groves, significant differences were also observed, but with higher marker values under tillage. Group 3 (DARN, QUIX, BERO, AIREN, CHIMENEA) did not exhibit significant management effects on the evaluated markers. Lastly, Group 4, represented solely by the ALCO olive grove, showed a differentiated response: nitrogen cycle markers (AOA, AOB, ureC) were unaffected by management, whereas BGH3 and phoD increased under cover cropping, and FGH3 under tillage.

These findings highlight the influence of both biotic and abiotic factors on soil microbial community structure. Despite the variability among farms (e.g., soil type), it is possible to identify consistent patterns that support the use of these molecular markers as predictive indicators of microbial abundance and functionality. Their application, especially when combined with enzymatic activity assessments, provides a valuable approach to evaluate the impact of agronomic practices on soil functioning in Mediterranean agroecosystems.

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GT 04 - 984 - P

IMPACTS OF WOODCHIP BIOCHAR AMENDMENT OF HARD-SETTING PORTUGUESE PASTURE SOIL TO SOIL FAUNA, AT AGRONOMICALLY REPRESENTATIVE APPLICATION RATES

GT 04. SOIL BIOLOGY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The addition of biochar to hard-setting soils can improve soil physical and chemical properties, namely reduce soil compaction, increase water retention, pH and nutrient availability. The impacts of soil amendment with biochar on soil biota are so far contradictory Beneficial or negative impacts are species-dependent, as influenced by biochar and soil properties, as well as application rate. Information on long-term impacts on soil macro and mesofauna are still absent or scarce, especially for hard-setting soils. The short-term and long-term impacts of woodchip biochar addition to hard-setting Portuguese pasture soil were investigated, at application rates that are relevant to agronomic applications (2%, 4% and 6% w/w), based on the responses of the earthworm Eisenia andrei (macrofauna) and in the enchytraeid Enchytraeus crypticus (mesofauna). Short-term exposures included avoidance behaviour and burrowing activity tests with E. andrei in freshly amended soil and aged amended soil (60 and 90 days). Long-term exposures included the earthworm reproduction test (28 days + 28 days) and a longer-term populational test (90 days) with E. andrei. Further, a multigenerational test was also conducted with E. crypticus (186 days). Results so far showed a significant preference behaviour of E. andrei to both freshly and aged biochar amended soil in all treatments. Further, it was a observed a significant increase in earthworms burrowing depth in both freshly an aged biochar amended soil at 4% and 6% w/w. Biochar chronic exposure (28 days) caused no effect on earthworms’ survival and biomass. Preliminary results from the multigenerational test showed no effect on adults’ survival and a significant increase in the reproductive output (F0 to F1). Interim results indicate a potential benefit of biochar amendment on pasture soil functions, while mitigating the effects of hard-setting to burrowing soil faunal groups that are representative of Mediterranean pastoral ecosystems.

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GT 04 - 1002 - P

THE HYPHAL TURNOVER IN FOREST SOILS: CATCHING UP WITH SOIL IMAGING AND AI IMAGE ANALYSIS

GT 04. SOIL BIOLOGY / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The turnover of hyphae greatly affects the accumulation and storage of carbon in forest soils. Observing and quantifying the turnover of hyphae is, hence, important for assessing the role of forests in climate change mitigation. Since the turnover rate of hyphae is up to 10 times per year, largely exceeding the one of roots, high-frequency measurement methods are required for accurately quantifying the hyphal turnover. However, there are few studies where such methods have been applied, and neither the specific measurement process nor the factors for an effective application are clear. In this presentation, I will discuss the high-frequency measurement of the hyphal turnover through a combination of automated soil imaging and AI image analysis (Figure 1) based on results obtained with a self-developed imaging device [1] in the field. I will introduce the measurement process and its bottlenecks and clarify the factors of an effective application considering the temporal and spatial variation of hyphal biomass in forests soils.

ACKNOWLEDGEMENTS

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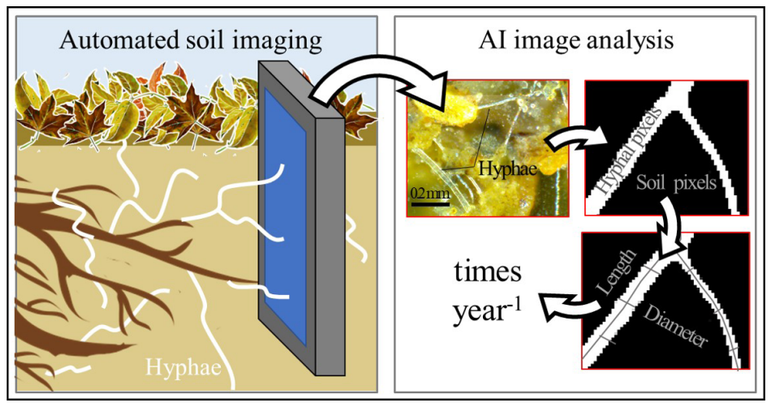


Fig 1. High-frequency measurement of the hyphal turnover in soil

GT 04 - 1034 - P

UNEARTHING SOIL MESOFAUNAL (COLLEMBOLAN) DIVERSITY ACROSS EUROPEAN FOREST

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Recent advances in DNA metabarcoding to identify multiple taxa from a bulked sample, facilitated the large-scale assessments and long-term monitoring of soil biodiversity. Methodological challenges remain, in particular when comparing molecular results with those derived from traditional morphologically based identifications. Often, DNA metabarcoding has recorded higher diversities than morphological analyses due to the presence of relict DNA and the detection of juvenile and fragmented specimens which highlights the need for methodological cross-validation of collembola and mites.

Here, we addressed this research gap by analysing soil collembola data derived from an European-wide large-scale survey of deciduous and evergreen forests. We compared soil DNA metabarcoding results with morphological data from 25 sampling sites across 16 countries and aimed to explore whether broad-scale environmental variables — such as latitude, elevation, forest type, climate, and soil characteristics — shape the diversity and community composition. These forest sites span a broad range of environmental conditions— including latitude, elevation, climate, soils, and forest types, and captures a diversity of temperate, boreal, alpine and Mediterranean ecosystems.

Our results revealed that diversity metrics (Richness and Shannon index) differed between the two approaches. However, both methods detected significant differences among forests, but produced similar results in community structure. Moreover, both approaches identified the same environmental variables — mean annual temperature, latitude, bulk density, pH, total C and C:N ratio — as the most influencing factors to explain the collembolan diversity and composition across European-wide forest soils. The findings of this research suggest that, although morphological assessment cannot yet be fully replaced, metabarcoding can effectively evaluate changes in collembolan communities caused by variations in soil properties.

Thus, soil DNA metabarcoding can serve as a reliable and efficient method for large-scale assessments of soil collembola where traditional morphological-based identifications are challenging. Nevertheless, although morphological analyses cannot yet be fully replaced, we emphasize the need to refine molecular methods (e.g. improvement of reference database and primer choice) to ensure the robustness of the data interpretations for their potential use in future soil biodiversity programmes and indicator taxa evaluation.



GT 04 - 1049 - P

MICROBIAL INTERACTIONS AND GHG FLUXES IN TROPICAL WETLANDS UNDER CONTRASTING HYDROLOGICAL REGIMES

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Wetlands play a key role in global carbon dynamics, acting as major carbon reservoirs and biogenic sources of greenhouse gases (GHG). The intensity of GHG emissions is closely linked to climatic variations and global warming [1]. Changes in soil microbial diversity can alter elemental cycling, impacting soil functions and ecosystem services [2]. This study evaluated microbial interactions in a permanent and a seasonal small wetland to explore how contrasting hydrological regimes affect microbial communities and GHG fluxes.

The sites are located in São Paulo, Brazil, in tropical highland climate areas once covered by Cerrado. At three points per wetland, CH4 and CO2 were measured, and soils were sampled for DNA extraction (Qiagen PowerSoil DNeasy). Sequencing (16S rRNA) was perfomed by Novogene America and taxonomic identification used QIIME2 [3] and SILVA [4]. Gas fluxes were monitored using static chambers and analyzed by gas chromatography.

We identified 48 bacterial phyla; 83% of sequences belonged to six dominant phyla: Acidobacteria, Actinobacteria, Bacteroidetes, Chloroflexi, Proteobacteria, and Verrucomicrobia. Microbial diversity differed significantly between wetlands (ANOVA; $p < 0.001$) but not between seasons. As shown in figure 1, the archaeal genus Methanocella presented negative correlation with CO2 and positive with CH4, being more abundant in the permanent wetland. Methermicoccus was also positively related to CH4 but only found in the permanent wetland. Spartobacteria and Thermoleophilia were negatively correlated with CO2, and their abundance linked to soil phosphorus, indicating nutrient competition under high CO2 fluxes. The bacterial groups Pedosphaerae and Gemmatimonadetes correlated positively with CH4, more abundant under reducing conditions, suggesting their role in providing substrates for methanogenic archaea.

The results emphasize the role of methanogenic archaea and bacterial consortia in CH4 production and highlight nutrient competition as a driver for community shifts under changing carbon fluxes.

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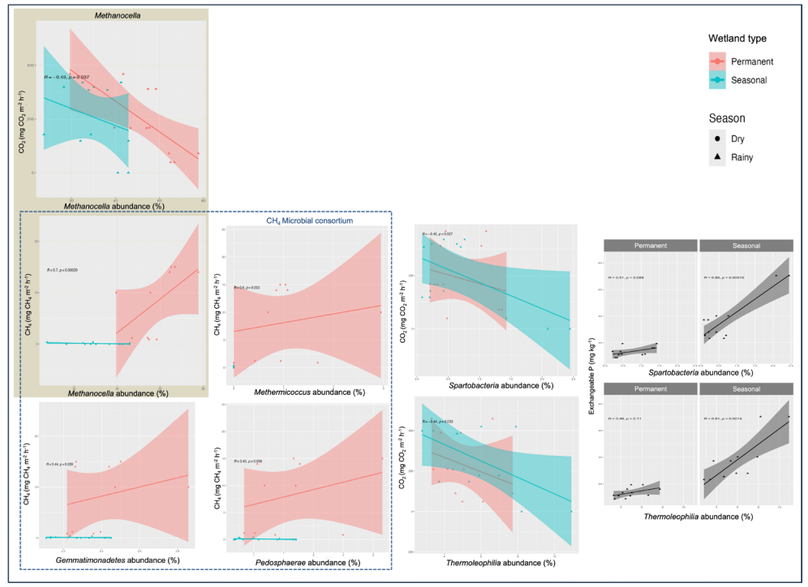
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Correlations between microbial taxa and GHG fluxes, highlighting the main groups contributing to CH4 production and the role of nutrient competition in shaping patterns across wetland types and seasons.



GT 04 - 1068 - P

HOW MANY SUSTAINABLE PRACTICES ARE NEEDED TO COUNTERACT THE NEGATIVE EFFECTS OF MULTIPLE ENVIRONMENTAL GLOBAL STRESSORS ON AGRICULTURAL SERVICES?

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Agricultural ecosystem services such as food production and carbon sequestration are threatened by multiple environmental global change stressors including increasingly intense heat-waves and droughts caused by climate change, and the excessive presence of chemicals linked to anthropogenic activity. Sustainable management is expected to contribute to supporting a sustainable agriculture under the current scenario of climate change. However, a question which remains to be answered is how many sustainable management practices would be needed to counteract the multiple effects of global change stressors on agroservices? Here, we conducted a field experiment to investigate the role of sustainable management practices in shaping the responses of cereal agroecosystems to multiple environmental stressors. We developed a full-factorial designed semi-field experiment exposing two major cereal crops: wheat and maize, to an increasing number of stressors (combinations of warming, drought, excess of nutrient fertilization, high salinity and pH, and heavy metals) and sustainable practices (combinations of additions of organic fertilizer, soil from a natural soil, biochar, arbuscular mycorrhizal fungi, cover crop, intercropping with legumes). Combinations of one, two, three and four stressors and sustainable practices were established. We investigate the effects of these multiple treatments on the biodiversity and ecosystem services of agroecosystems including carbon sequestration, nutrient cycling, organic matter decomposition, fungal diversity, crop yield, and plant health. Preliminary results suggest that multiple management practices may be needed to handle the effects of environmental stress on agroecosystem services with consequences for the sustainability of agriculture under global change. Altogether, our results provide new insights on how global change factors affect soil biota and processes and how sustainable management can guide the future of sustainable agriculture under global change.

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GT 04 - 1108 - P

SOIL MICROBIAL COMMUNITIES IN CITRUS AND AVOCADO AGROECOSYSTEMS.

GT 04. SOIL BIOLOGY / GT 09. SOIL HEALTH

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Soil microorganisms play a fundamental role in organic matter decomposition, nutrient cycling, and plant and soil health. They are particularly active in the rhizosphere, whose structure and function are shaped by interrelated factors, such as crop species, soil characteristics and management practices, all of which influence microbial diversity and abundance.

In southern Portugal, citrus (Citrus spp.) and avocado (Persea americana Mill.) are key permanent crops. Although avocado and citrus orchards are similar in general management, there are differences in soil management that can lead to the development of different soil microbial communities. In citrus orchards, rows are often managed through mechanical or chemical weed control. In contrast, the natural defoliation of avocado trees forms a layer of persistent biomass that covers the rows, reducing the needs for active weed control and keeping soil better protected from erosive agents and radiation. These contrasting practices result in different levels of soil organic matter (SOM) accumulation and can influence the soil microbial communities.

To compare the soil microbial communities on these two agroecosystems, soil samples were collected under trees (rows) on citrus and avocado orchards located side by side. Total fungi and bacteria, with focus on Actinomycetes class, populations were quantified as colony-forming units (CFU).

In the avocado orchard, where SOM was significantly higher (4,8%), fungal abundance reached 6,69 × 106 cfu·g^{-1} soil, compared to the citrus orchard with lower SOM (3,6%) and a significantly reduced fungal abundance of 1,82 × 106 cfu·g^{-1} soil. Conversely, both bacterial and Actinomycete populations were higher in the citrus orchard, with counts of 7,90 × 10^6 cfu. g^{-1} soil and 5,43 × 10^6 cfu. g^{-1} soil, respectively, compared to the avocado orchard, where they declined to 3,24 × 10^6 cfu. g^{-1} soil and 3,86 × 10^6 cfu. g^{-1} soil. These findings indicate that differences in crop-specific factors, including root exudates, and soil management practices, may influence microbial communities, leading to the dominance of distinct microbial groups.

The metagenomic analysis of these soil samples, currently under development, will enable the assessment of alpha and beta diversity within the soil's microbial communities. Additionally, periodic soil sampling will be conducted to monitor SOM, track shifts in microbiome dynamics and evaluate the incidence of Phytophthora cinnamomi, a major soil pathogen affecting both crops. Deciphering the structure and function of soil microbial communities in citrus and avocado orchards will be essential for the development of more sustainable and resilient agroecosystems.

KEYWORDS

Citrus spp.; Persea americana; Soil habitat; Soil management; Soil organic carbon; Rhizosphere.

ACKNOWLEDGEMENTS

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GT 04 - 1112 - P

FAIRY RINGS IN THE GARDENS OF THE ROYAL PALACE OF CASERTA (ITALY): SOIL PROPERTIES AND MICROBIOME ASSOCIATED WITH MYCELIUM OF THREE SPECIES OF BASIOMICETEAE

GT 04. SOIL BIOLOGY / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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In stable meadows, the biological phenomenon of fairy rings (FR) are generated by the mycelium growth of basidiomycete fungi. The mycelium expands underground colonizing new spaces outwards and, consequently, the soil becomes crumbly, whitish, and with a characteristic odour. The presence of FRs also causes a change in the vegetation on mycelium development fronts and the presence of fungal sporophores. FR are classified according to their effect on vegetation:

- Type I, they first cause suppression of vegetation at the fungal front and then a stimulation after the passage;
- Type II, they induce a stimulation of the vegetation;
- Type III, they cause no effect.

In November 2021, three FRs formed by three different basidiomycetes were observed in the gardens of the Royal Palace of Caserta. Thus, the soil microbial population and chemical and biochemical properties were studied. Different species formed the three FRs: Marasmius oreades (Type I), Amanita vittadini (Type II), and Clitocybe collina (Type III). The presence of different fungal species in the same biological forms allowed comparing the effect of macro fungi on soil. For each FR the soil sampling were carried out at three different points in the ring and five replicates per position: i) in an area where no fungal passage occurred (OUT), ii) at the fungal front (ON), and iii) where mycelium passage occurred one meter from the fungal front (IN). The presence of the fungi led to soil acidification and an increase in electrical conductivity, linked to an increase in nutrients, as demonstrated by an increasing bioavailability for each nutrient. Organic carbon, microbial biomass, and soil respiration increased in the presence of fungal mycelium. Based on the enzymatic activity of the laccase and Mn peroxidase, a different lignin degradation strategy arose according to the present fungal species.

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GT 04 - 1127 - P

BIOCRUST MICROBIOMES PROMOTE RESTORATION OF DRYLAND PLANT COMMUNITIES UNDER DROUGHT AND SALINITY STRESS

GT 04. SOIL BIOLOGY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil degradation and biodiversity loss are increasingly urgent challenges under climate change, particularly in Mediterranean drylands where desertification is accelerating due to rising temperatures, water scarcity, and salinization. These stressors hinder native vegetation establishment and disrupt soil microbial networks that are essential for ecosystem functionality. While rhizospheric and endophytic microbial communities have been extensively studied in ecological restoration, the potential of biological soil crusts (biocrusts)—complex surface assemblages of cyanobacteria, bacteria, and other microorganisms—remains underexplored.

In this study, we investigated the use of native biocrust-derived microorganisms as bioinoculants to enhance germination and early growth of native plant species under abiotic stress. Cyanobacteria (e.g., Pseudoaliinostoc, Nodosilinea) and bacteria (e.g., Bacillus, Kushneria, Fredinandcohnia, Rossellomorea) were isolated from biocrusts collected in two representative Mediterranean regions: southeastern Spain and western Sardinia (Italy). Strains were selected for key plant growth-promoting (PGP) traits, including nitrogen fixation, phosphorus solubilization, and phytohormone production.

Microbial consortia were applied via seed biopriming to native species relevant for restoration: Thymus hyemalis, Genista umbellata, Juncus acutus, Arthrocaulon meridionale, and Mentha aquatica. Microcosm experiments were conducted under controlled drought and salinity stress (up to 0.7 M NaCl) and increased temperatures (25°C and 30°C), simulating future climate conditions. Results showed that biocrust-derived microbes significantly improved seed germination and early root growth, enhancing plant resilience under harsh environments.

All inoculants increased germination rates across species. In T. hyemalis, microbial consortia boosted both final germination percentage and speed, with particularly strong effects at 30°C. Inoculated seedlings also showed improved root development at both temperature regimes. For G. umbellata, bacterial consortia did not significantly improve final germination but did accelerate it at 25°C and enhanced early root elongation at 30°C. In A. meridionale, cyanobacteria increased germination by 7% over control at 0.5 M NaCl and were the only treatment supporting germination at 0.7 M. In J. acutus and A. meridionale, cyanobacteria maintained low germination (2%) at 0.7 M, while no germination occurred in controls or bacterial treatments. M. aquatica was highly salt-sensitive, germinating only under non-saline conditions, where cyanobacteria and PGP bacteria improved germination by 15% and 4%, respectively. Under non-saline conditions, seedlings inoculated with cyanobacteria developed the longest roots (e.g., 22.9 mm in M. aquatica vs. 13.6 mm in the control).

This study highlights the promising role of biocrust microbial communities in restoring degraded soils and promoting the establishment of native vegetation. The use of indigenous microorganisms offers an effective, low-impact approach particularly suited to ecosystems affected by drought and salinity. Future field trials will assess long-term effectiveness and scalability for broader landscape restoration.

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GT 05. SOIL HYDROLOGY & EROSION

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 05 - 148 - O

DIFFERENTIAL EROSION PATTERNS IN CHERNOZEMS AND CAMBISOLS: IMPACT OF SLOPE MORPHOLOGY AND IMPLICATIONS FOR STRIP CROPPING DESIGN

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Water erosion significantly impacts agricultural soils worldwide, yet the differential effects on various soil types remain understudied. This research investigates the contrasting impacts of erosion processes on Chernozems and Cambisols, focusing on their distinct slope morphologies in South Moravia and the Bohemian-Moravian Highlands, Czech Republic. Our comprehensive study combined field sampling, laboratory analyses, and geospatial modeling to examine physical, chemical, and biochemical soil properties across erosion, transport, and deposition zones on different slope types. The research revealed significant differences in erosion patterns between Chernozems on concave-convex slopes and Cambisols on convex-concave slopes. Chernozems exhibited higher erosion rates (33.0 ± 14.1 t/ha/year) compared to Cambisols (14.0 ± 5.6 t/ha/year), with more pronounced differences between erosion and deposition zones. The distinct slope morphologies played a crucial role: concave-convex slopes with Chernozems showed accelerated runoff patterns leading to extensive erosion zones (76%) and concentrated deposition areas (20%), while convex-concave slopes with Cambisols demonstrated more balanced distribution patterns with dominant transport zones (69%). Analysis of soil properties revealed significant variations in organic carbon redistribution, enzyme activities, and nutrient transport between the two soil types. Chernozems showed more intensive organic matter transport to deposition zones and higher enzymatic activity gradients compared to Cambisols. These differences are attributed to both inherent soil properties and the characteristic slope morphologies where these soil types typically occur. The findings emphasize the need for soil type-specific erosion control strategies. Strip cropping emerges as a promising adaptive measure that can be parameterized according to soil type and slope morphology. Based on agent-based modeling (ABM) simulations of water erosion on fields with strip cropping patterns, specific design parameters were developed. For Chernozems on concave-convex slopes, narrower strips are required due to higher erosion susceptibility and specific runoff dynamics, while for Cambisols on convex-concave slopes, wider strips can be effectively implemented due to their characteristic slope morphology and more balanced erosion patterns. This targeted approach to erosion control, considering both soil type and slope morphology, offers enhanced protection while maintaining agricultural productivity. The implementation of soil type-specific erosion control measures, particularly parameterized strip cropping, represents a significant step toward sustainable soil management in erosion-prone areas.

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GT 05 - 210 - O

PEDOTRANSFER FUNCTIONS FOR FOREST SOIL IN CZECHIA

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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This study aims to develop and compare pedotransfer functions (PTFs) for predicting soil hydrological properties in forest and agricultural soils in Czechia. Historically, there has been a significant disparity in the amount of data available for arable land versus forest areas, with forest data being considerably less abundant.

The research utilizes a database of 862 forest soil samples and 143 agricultural soil samples. Water retention properties of forest soils were measured using a national method and transformed to a standard pressure head using established equation. Explanatory variable were key soil properties such as bulk density, texture, organic carbon content. The study employs Random Forest models to predict soil hydrological properties at specific pressure heads.

The results indicate that bulk density is the most critical variable for both forest and agricultural models, with clay content also being significant. The models were evaluated using RMSE and sMAPE (symmetric mean absolute percentage error) metrics, showing that forest models generally perform worse (sMAPE 8.0% - 9.7%) compared to agricultural models (sMAPE 3.3% - 8.6%). When the models were applied to external data (forest models on agricultural data and agricultural models on forest data), forest models demonstrated greater robustness and smaller performance reduction. Moreover, forest data are better predicted by forest model than by agricultural models.

This research highlights the importance of developing specific PTFs for forest soils to improve the accuracy of hydrological predictions and supports better landscape management practices.

ACKNOWLEDGEMENTS

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GT 05 - 258 - O

THE HYDROLOGY AND SEDIMENT ANALYSIS AT SELECTED LOCATIONS OF IMO RIVER, IMO STATE, IN SOUTHEASTERN NIGERIA.

GT 05. SOIL HYDROLOGY & EROSION / GT 02. SOIL PHYSICAL CHEMISTRY

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There is a growing concern on the pitiable level of degeneration of water quality for irrigation and domestic purposes occasioned my incessant anthropogenic activities that have contributed to this menace. This Current investigation aims at insight about the level of contaminants of surface water and sediment analysis of selected locations of Imo river of imo State of Southeastern Nigeria over a twelve months period. The physico-chemical analysis was employed to assess the water and sediment quality of the samples. Air-shade temperature (28.6 - 29.6 0C), Surface Water Temperature (26.8 - 27.4 0C), pH (6.2 - 6.6), Electrical conductivity (24.3 - 44.2 µscm-1), Total Dissolved Solid (11.8 - 21.1mgl-1), Total Hardness (82.3 – 99.6 mgl-1),Total Alkalinity (25.1 -39.2 mgl-1), Dissolved Oxygen (5.6 -7.8 mgl-1), Biochemical Oxygen Demand (2.5 - 3.7 mgl-1), Chloride (22.7 - 29 mgl-1) , Nitrate (0.4 -0.6 mgl-1), Sulphate (11.2-14.9 mgl-1), Silica (1.2 - 2.6 mgl-1), Total phosphorus (2.2-29 mgl-1), Potassium (1.5 - 2.5 mgl-1), Sodium (2.3 - 4.2 mgl-1), Calcium (0.6 - 1.02 mgl-1), Magnesium (0.9 - 1.3 mgl-1) , Zinc (0.01 - 0.02 mgl-1), Iron (0.14-0.50mgl-1) and Manganese(0.0 - 0.07mgl-1),while the following ranges were recorded for sediment: Temperature (27.6 - 28.6 0C), pH (5.5 - 5.8), Conductivity (93 - 211 µscm-1), Total Dissolved Solid (45.2 - 105 mgkg-1 DW), Manganese (2.4 – 19.5 mgkg-1 DW), Zinc (0.20 - 6.1 mgkg-1 DW), Iron (0.11 – 0.52 mgkg-1 DW), Potassium (5.76 - 11.8 mgkg-1 DW), Sodium (19.9 - 22.3 mgkg-1DW), Calcium (48.7 - 93.9 mgkg-1DW), Magnesium (3.6 -87.2 mgkg-1DW), Copper (0.0 - 0.01 mgkg-1 DW), Cadmium (0.0 -0.05 mgkg-1DW) and Arsenic (0.0 - 0.01 mgkg-1DW). All the values recorded for the physico-chemical parameters were within the range recorded for other water bodies of lower Niger Delta Region. They also fall within the permissible limit of S.O.N., W.H.O, E.U. and U.S.E.P.A. Standards except for dissolved oxygen and Ortho-phosphate phosphorus that slightly deviated. The Cationic order recorded for water column was: Na>k>Ca>Mg, While sediment cationic order was Ca >Na> Mg>K, with PFARSALL 'S Index of 6.96mgl-1 (water) and 128.29 mgkg-1DW sediment. Air-Shade Temperature, Surface Water Temperature, Conductivity, T.D.S, Transparency, Total Hardness, D.O.,B.O.D., Chloride, Sulphate, Silica, Magnesium and Calcium showed monthly significant differences ($p< 0.05$), while Conductivity, T.D.S, Transparency, Silica and Calcium showed station/station significant differences ($P < 0.05$). Positive significant correlation were observed between Air-Shade Temperature and Total hardness, as well as dissolved oxygen with chloride ($p <0.05$). The positive relationships observed depicts an interplay between the overlying water and the bottom sediment.

ACKNOWLEDGEMENTS

I am grateful to the Government of Nigeria for sponsoring this conference.

GT 05 - 324 - O

HOW SOIL ORGANIC MATTER, HYDROPHOBICITY AND HYSTERESIS INTERACT IN SANDY SOILS

GT 05. SOIL HYDROLOGY & EROSION / GT 02. SOIL PHYSICAL CHEMISTRY

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Hydrophobicity and hysteretic behavior of the unsaturated soil have impacts on the soil water balance. In light of climate change, these impacts will become even more relevant, as extreme weather conditions such as more frequent heavy rainfall events and more pronounced droughts will increase in Central Europe. In sandy soils, soil organic matter (SOM) has been shown to increase plant available water storage of soils but it can also affect hydrophobicity and hysteretic behavior. The aim of this study is to characterize how hysteretic effects and hydrophobicity in sandy soils are influenced by the SOM content and how they affect each other. We further seek to identify possible interrelations between hysteresis and hydrophobicity. Understanding this linkage is crucial for improving the prediction of the soil water balance under changing climatic conditions.

To answer the research question how and to what extent hydrophobicity and the hysteretic behavior of sandy soils, is influenced by soil organic matter, we analyzed samples taken in the South-east of the Metropolitan region of Hamburg, near Lüchow-Dannenberg. Sites with a high sand content (> 80% sand) and a wide range of SOM contents (0.1-6.0%) under different land use classes were identified. Hydrophobicity was analyzed using the water-drop-penetration-time test and contact angle measurements with the sessile drop method. To quantify the hydrophobicity under different moisture levels, the Integrative Repellency Dynamic Index (IRDI), using the MED test, was determined for all topsoil samples (0-10 cm). The drying and rewetting behavior of the soil water retention curves were measured with the HYPROP© device. The rewetting curves were determined by stepwise rewetting until saturation.

We show that the SOM content has a strong positive correlation with hydrophobicity. Soil samples so far analyzed for hysteresis show that that SOM content does not increase the hysteresis effect of soil samples. Following up on this research we will determine the potential effect of hysteresis on the results of the soil water balance for modeling under different predicted climate scenarios.

ACKNOWLEDGEMENTS

The study is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2037 'CLICCS - Climate, Climatic Change, and Society' – Project Number: 390683824, contribution to the Center for Earth System Research and Sustainability (CEN) of Universität Hamburg".



GT 05 - 381 - O

FIELD-SATURATED SOIL HYDRAULIC CONDUCTIVITY ACROSS SUB-SAHARAN AFRICA: FROM CONTINENTAL PATTERNS TO FILLING DATA GAPS IN GRASSY BIOMES

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Understanding soil hydraulic functioning is essential for managing water resources and ensuring the provision of critical ecosystem services. Field-saturated hydraulic conductivity (Kfs) governs infiltration, soil moisture, and runoff, yet remains poorly documented in tropical regions. In our recent study [1], we addressed this gap by assembling the largest known dataset of Kfs measurements across sub-Saharan Africa—over 3,500 plots from 83 sites across 19 countries sampled systematically using the Land Degradation Surveillance Framework [2].

Our results indicate that, while soil texture was a strong predictor of Kfs, variables related to soil structure and land management—such as soil organic carbon (SOC), woody cover, erosion, and grazing intensity—also played key roles. This suggests great potential to enhance soil infiltration and hydrological function through management and restoration practices that improve soil structure.

To explore mechanisms behind these relationships, we analyzed LDSF data from agricultural landscapes in Kenya. Our findings showed that Kfs was positively associated with both SOC and the functional traits of woody vegetation [3,4], indicating that not only the presence but also the characteristics of vegetation influence soil hydrological function.

Interestingly, in the continental dataset, grasslands exhibited the lowest Kfs values—even lower than croplands. This contrasts with earlier studies and likely reflects sampling bias toward degraded grasslands. To address this, we are expanding LDSF sampling in grassy biomes through projects such as Restore4More and UK Pact Nature-based solutions. New data from rangeland ecosystems—including communal grazing land and protected areas—will help us better understand variation in Kfs across these underrepresented ecosystems.

This work strengthens the evidence base for improving land and water management across sub-Saharan Africa.

ACKNOWLEDGEMENTS

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GT 05 - 390 - O

AGRICULTURAL LAND LACKS RESISTANCE TO WATER EROSION DURING THE WETTEST WINTERS OF THE LAST DECADE

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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With changing climate and increased frequency of wet weather extremes, increased attention is being directed towards understanding the resilience of agroecosystems and the goods and services they deliver. The world's most instrumented and monitored farm (the North Wyke Fam Platform - a UK National Bioscience Research Infrastructure) has been used to explore the resilience of sediment loss regulation delivered by lowland grazing livestock and arable systems under conventional best management. The robustness of water quality regulation was explored using exceedance of modern background (i.e. pre-World War II) net soil loss rates (i.e., sediment delivery) during both typical (2012-13, 2015-16) and the most extreme (2013-14, 2019-20, 2023-24) winters (December - February, inclusive), in terms of seasonal rainfall totals, over the past ~decade. Exceedances of maximum modern background sediment loss rates from pasture were as high as 2.4X when scheduled ploughing and reseeding for sward improvement occurred immediately prior to the winters in question. Exceedances of maximum modern background sediment loss rates in the arable system (winter wheat and spring oats) were as high as 21.7X. Over the five monitored winters, the environmental damage costs for cumulative sediment loss from the permanent pasture system ranged from £163-203 and £197-245 ha-1 to £321-421 and £386-507 ha-1. Over the same five winters, environmental damage costs for cumulative sediment loss from catchments subjected to reseeding and, more latterly, arable conversion, ranged between £382-584 and £461-703 ha-1 to £1978-2334 and £2384-2812 ha-1. Our data provide valuable quantitative insight into the impacts of winter rainfall and land use on the resilience of sediment loss regulation.

ACKNOWLEDGEMENTS

We gratefully acknowledge the funding provided by UKRI-BBSRC (UK Research and Innovation-Biotechnology and Biological Sciences Research Council) via grant awards BBS/E/RH/230004B - Resilient Farming Futures: Detecting agroecosystem 'resilience' using novel data science methods and BBS/E/RH/23NB0008 – the North Wyke Farm Platform National Bioscience Research Infrastructure (NBRI).





GT 05 - 582 - O

SOIL WATER RETENTION CURVE USING A DIELECTRIC PERMITTIVITY REGRESSION

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The monitoring and understanding of the movement of water through soil has broad applications not limited to irrigation and food security, flood risk, landslide rick assessment and wildfire risk management and many other applications relating to water resources. The Richards Equation has become one of the most common ways to describe and quantify the transient movement of water in unsaturated porous media. The Richards Equation contains the unsaturated hydraulic conductivity parameter. The unsaturated hydraulic conductivity is important for both physical based models such as HYDRUS and for machine learning statistical based models to predicting soil moisture. Hydraulic conductivity is determined from a water retention curve which is a plot of soil moisture verses unsaturated hydraulic head. The numerical solution for the unsaturated hydraulic conductivity from the water retention curve is the van Genuchten equation. The water retention curve, however, is often difficult to obtain in the laboratory and difficult to apply to soil moisture data in the field. A new fixture called The Travel Assembly has been developed to hold a soil sensor in a soil sample during the laboratory development of a soil water retention curve. The Travel Assembly consists of a soil core sample in a metal ring of known volume, an SDI-12 HydraProbe soil sensor, and a mesh on the bottom holding the soil sample in place while allowing the exchange of water in and out of the sample. The Travel Assembly can be placed on low tension hanging water column tables and in pressure extractors that can be pressurized up to 1500 kPa. For saturation, the Travel Assembly can be placed in a Tempe Cell. The dielectric permittivity, which is the raw electrical parameter used for soil moisture determination, is measured at every pressure condition. The resulting soil water retention curve consists of soil moisture determined gravimetrically, pressure, and the dielectric response form the HydraProbe Soil Sensor. Upon completion of the soil water retention curve, HydraProbes in the field in the same soil tested are able to measure soil moisture very accurately with a custom calibration, and unsaturated hydraulic head. Six soil samples, a Columbia silt loam alfisol, were placed in the Travel Assembly and evaluated at saturation and 10 pressures ranging from 0.01 to 5 Bar. The technique was perfected to generate a soil water retention curve with minimal error.

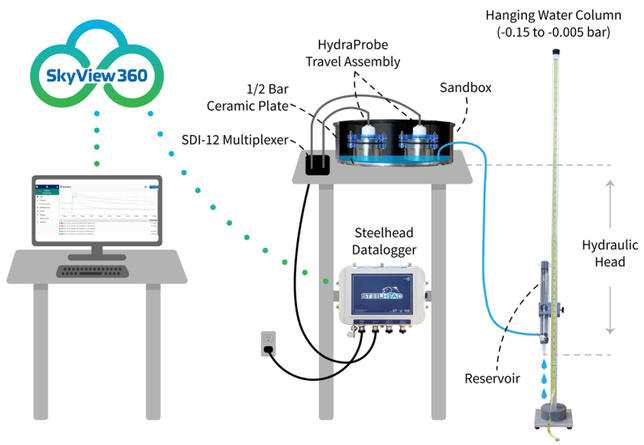
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GT 05 - 1137 - O

SOIL EROSION IN THE EU: A GROWING CONCERN FOR A SUSTAINABLE FUTURE

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION -CONSERVATION, MITIGATION, REMEDIATION

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Over the past decade, the JRC has developed an updated version of the Revised Universal Soil Loss Equation (RUSLE) model to assess soil loss in Europe for the reference year 2010. This model incorporates the most recent pan-European datasets for input factors such as rainfall erosivity, soil erodibility, cover-management, topography, and support practices (Panagos et al., 2015). The RUSLE2015 model has been used to estimate soil loss due to water erosion for the years 2000, 2010, and 2016, with ongoing assessments for 2023. Recent estimates (Panagos et al., 2020) indicate that the average soil loss from water erosion in the European Union is approximately 2.4 t ha-1 yr-1, reflecting a 9% decrease since 2000. This positive trend is attributed to the implementation of enhanced soil protection management practices in agricultural areas, which are associated with the Good Agricultural and Environmental Condition (GAEC) requirements of the Common Agricultural Policy.

A research gap existed for wind erosion due to lack of continental assessments. To enhance understanding of this issue, the JRC assessed land vulnerability to wind erosion (Borrelli et al., 2017) utilizing the RWEQ model. Additionally, the JRC has made significant strides in quantifying soil loss resulting from crop harvesting (Panagos et al., 2019), tillage erosion (Borrelli et al., 2023), losses following fires (Vieira et al., 2024) and gully erosion (Borrelli et al., 2025). These developments have facilitated a better understanding of the geography and interplay of various erosion processes in Europe, encompassing water erosion, wind erosion, soil loss from crop harvesting, and tillage erosion (Borrelli et al., 2023).

Looking ahead, soil loss due to water erosion is projected to increase by 13-22.5% in the EU by 2050, primarily due to increased rainfall intensity (Panagos et al., 2021). Depending on the Representative Concentration Pathways (RCP2.6, 4.5, 8.5), rainfall intensity is expected to increase by an average of 15.7-25.5% in the EU, leading to analogous increases in soil erosion.

To address these challenges, the EU Soil Observatory continues to further develop the EU Soil Erosion Modelling (EUSEM) Platform, which advances our understanding of soil erosion in the EU and provides better spatio-temporal estimates of soil erosion to support policies such as the Soil Monitoring Law, Common Agricultural Policy, and Sustainable Development Goals (SDGs). EUSEM is designed to provide a comprehensive framework for assessing soil erosion and support the effective strategies for conservation

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GT 05 - 716 - F + P

SEDIMENT RATING CURVE DYNAMICITY AT FIELD SCALE: INSIGHTS INTO THE RESILIENCE OF AGRICULTURAL LAND TO SEDIMENT LOSS?

GT 05. SOIL HYDROLOGY & EROSION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Agricultural soils are suffering from intensive management and environmental pressures threating both production and regulating functions. Robust land in terms of sediment loss regulation is vital for reducing sediment pressures on aquatic environments. However, explicit evaluations of the robustness of agricultural land for sediment loss regulation are scant, limiting the broader understanding of soil resistance against erosion in the context of changing climate. This study therefore investigated changes in soil drainage season turbidity (Tn) and flow (Q) relationships through time using dynamic linear models which provide insights into the overall degree of Tn-Q dynamicity. Dynamicity values (δ) remained highly variable and inconsistent through time, signifying this parameter is not sufficiently sensitive to detect changes in Tn-Q over soil drainage seasons at the field scale. However, the dynamics of the intercept and slope coefficients in the linear models confirmed that tilled soil had significantly lower resistance against erosion and saturation-excess runoff further reduced sediment loss regulation compared to its neighbouring grassland. Moreover, soil moisture analysis revealed soil saturation increased sediment availability and loss from arable land. This study is the first to directly assess the robustness of agricultural land for sediment loss regulation using dynamic linear models at field scale. Our work reveals the decreased robustness of sediment loss regulation associated with grassland conversion to arable agriculture.

ACKNOWLEDGEMENTS

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GT 05 - 85 - P

SEASONAL AND MULTI-TARGET SEDIMENT CONNECTIVITY IN HEADWATER BASINS WITH TRADITIONAL WATER-MEADOWS (LAMEIROS)

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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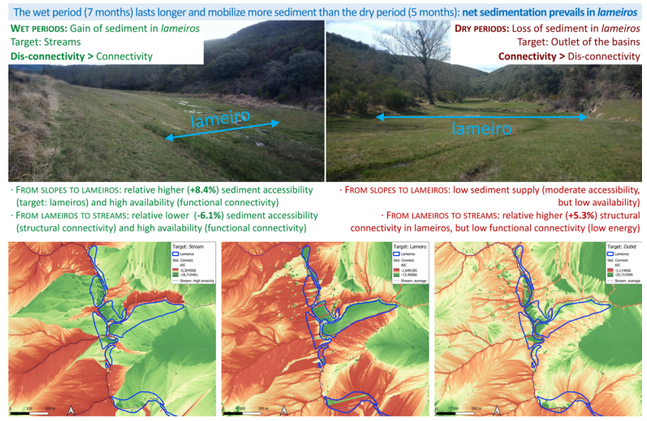
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Lameiros are traditional man-made water-meadows located at the bottom of the valleys in northern Portugal and northwestern Spain. Although lameiros act as hydrological and sediment accumulation regulators, the temporal variation of this process has never been quantified in a spatially distributed manner. For the first time, the role of lameiros in sediment connectivity is calculated by using the aggregated index of sediment connectivity (AIC) in two medium-size ungauged headwater basins with permanent and seasonal streams. Index parameterization was done in detail, including field surveys to distinguish the type, in-use (n=21) or abandoned (n=78), of lameiros and their water availability, well (n=89) or poor (n=10) irrigated. Different sedimentological scenarios that occur throughout the year were computed considering the net soil loss at the basin scale (target: watercourses; common conditions with the whole basin activated) and temporary accumulation in watercourses (target: outlet; dry conditions with sediment transport limited to the streams). The three erosive periods that happen during the year, i.e. high, medium and low rainfall erosivity, were simulated with long, average and short watercourses. Results of structural connectivity proved that the role played by each input (land-use, soil permeability, rainfall erosivity, slope gradient, drainage area, roughness of the terrain) on sediment connectivity strongly depended on the spatial location of each landscape unit regarding the selected target and not only on their own values. This fact explained the lower connectivity obtained in the abandoned lameiros than that found in the in-use lameiros. Map analysis indicated that during the dry period from May to September overland flow was restricted to the streams, sediment supply from slopes to lameiros was limited and the temporarily accumulated sediment in lameiros may be remobilized, while during the wet (January-April) and rainy (October-December) periods sediment supply from active slopes to lameiros was high and sediment delivery from lameiros to stream was relatively lower, acting as sedimentation-prone areas. Indeed, poor-irrigated lameiros had greater connectivity than well-irrigated lameiros. Connectivity of lameiros with their contributing areas (target: lameiros) was higher than that of the remaining land uses with the outlet and watercourses, proving the high sediment accessibility of this landscape feature. Index output performed well against available data of soil depth measured both in the lameiros and slopes. Multi-target computation of structural and functional connectivity concluded that sedimentation in lameiros prevailed against sediment delivery, although both processes occurred simultaneously throughout the year. This study suggests the convenience of preserving lameiros with some form of legal protection.

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Sediment delivery and accumulation dynamic in the lameiros and slopes throughout the year.



GT 05 - 103 - P

NITRATE LEACHING UNDER NO-TILLAGE AND CONVENTIONAL TILLAGE PRACTICES IN CORN-SOYBEAN ROTATION

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Nitrate-nitrogen (NO3-N) Leaching beyond the root zone into the groundwater is a an environmental concern. A field study was conducted to investigate the effect of no-tillage (NT) and conventional tillage (CT) practices on seasonal drainage fluxes and NO3-N leaching losses below the root zone in irrigated corn and soybean on sandy loam soil. Sixteen passive capillary lysimeters, PCAPs (75 cm long × surface area of 0.1 m2) were placed 90 cm below the soil surface to measure percolated drainage water below the root zone of corn-soybean rotation under NT and CT practices. The study was designed as a randomized complete block with four replications. Drainage and NO3-N fluxes were not significantly affected by the tillage in 2014, 2015, 2016, 2017, 2018 and 2019 due to large spatial variations among lysimeters within each treatment. Average seasonal drainage amounts across 6 yrs were 36.2 and 49.7 mm for corn and 40.2 and 36.7 mm for soybean under NT and CT, respectively. Averaged 6-yr cumulative NO3-N losses were 13.5 and 23.3 kg ha-1 for corn and 16.5 and 19.2 kg ha-1 for soybean under NT and CT, respectively. Flow-weighted NO3-N concentrations over 6 yrs were 30.9 and 36.8 mg L-1 for corn while those for soybean were 50.9 and 38.3 mg L-1 under NT and CT, respectively. Nitrate-nitrogen concentrations generally exceed the safe drinking water standard of 10 mg L-1. Reducing N inputs in well-drained soils and using site specific N and irrigation management practices are essential to lower input expenses, reduce N leaching and sustain environmental quality.

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GT 05 - 130 - P

IDENTIFICATION OF EROSION HOTSPOTS AND SCALE-DEPENDENT RUNOFF CONTROLS ON SEDIMENT TRANSPORT IN AN AGRICULTURAL CATCHMENT

GT 05. SOIL HYDROLOGY & EROSION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Understanding how agricultural land management influences sediment transport is crucial for identifying critical source areas (CSAs) and improving erosion mitigation strategies. While numerous studies focus on in-stream sediment concentrations, fewer investigate overland flow on the hillslopes. We monitored streamflow and sediment fluxes at an overland flow station (E2) and an in-stream station (MW) across 55 runoff events (2011–2022) in the Hydrological Open Air Laboratory (HOAL), Austria. The catchment was segmented into four distinct areas (A, B, GW9, C) based on topography, hydrological connectivity, and proximity to the stream, allowing a spatially explicit assessment of erosion hotspots. Temporal patterns of sediment transport were analysed to infer spatial variability, and differences in sediment transport dynamics among areas were quantified using Kruskal-Wallis tests and effect size analysis. Results suggest that at E2 (hillslope scale), non-erosive cultivation significantly reduced peak turbidity (~9.5 times) and sediment load (~3.8 times) in flat agricultural areas (7.34% slope, <500 m from the stream) but had no measurable effect in steep (10–12% slope) or distant (>1000 m) agricultural areas. Across all field types, conversion to non-erosive cultivation did not affect peak flow. At MW (catchment scale), compared to E2, peak turbidity at MW decreased (~5.4–7.7 times) due to dilution from subsurface flow contributions, while peak flow increased (~2.8–11 times) due to additional inputs from wetlands, springs, and subsurface flows. Sediment load at MW was ~2.4–5.4 times higher than at E2, likely due to unmonitored diffuse overland flow and sediment inputs from tile drainages. Our findings indicate that non-erosive cultivation alone in steep terrains or distant agricultural areas is insufficient to effectively mitigate sediment transport. Effective sediment management in agricultural catchments requires spatially targeted erosion control strategies that account for topography, hydrological connectivity, and field proximity to streams.

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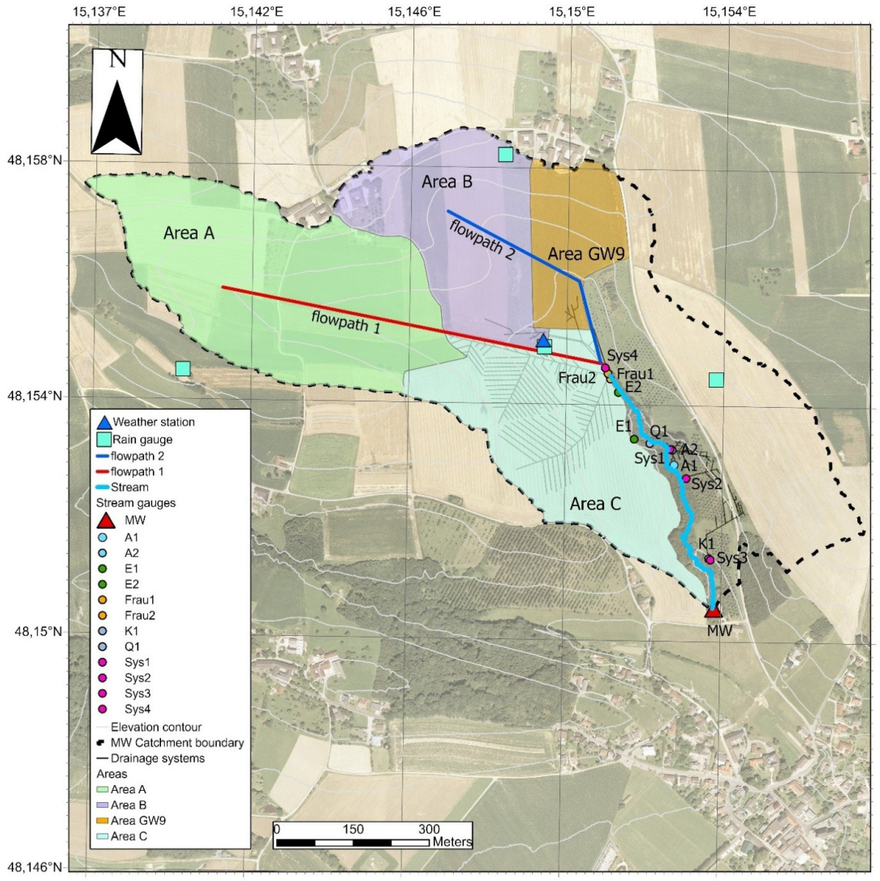
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Methodology

GT 05 - 155 - P

EFFECTS OF MULCH AND BIOCHAR ON SOIL HYDROLOGIC RESPONSE IN MEDITERRANEAN AGROECOSYSTEMS

GT 05. SOIL HYDROLOGY & EROSION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Agricultural intensification in Mediterranean Europe exacerbates soil hydrologic degradation, amplifying runoff-driven erosion, diminishing water storage capacity, and threatening agroecosystem resilience under climate change. While both mulch and biochar have been shown to improve soil hydrology, the combined effects of these amendments remain insufficiently tested under field conditions. Furthermore, conventional runoff quantification methods, such as storage tanks or tipping-buckets, lack precision for capturing dynamic hydrological responses.

The main objective of this study, within the scope of the SOLVO and SOLVIT projects, was to evaluate the impact of mulch and biochar on soil hydrologic response, under two different treatments: (i) a mulch layer (2 Mg ha^{-1} straw/olive leaves) and (ii) a mulch + biochar layer (2 Mg ha^{-1} straw/olive leaves mulch over 10 Mg ha^{-1} biochar), with untreated soil serving as the control. Over one year, we measured field runoff (using pressure sensors), soil moisture (via a portable sensor), and soil water repellency (using the Water Drop Penetration Test method) in sandy loam soils at two Mediterranean farming sites: a vineyard and an olive orchard in southern Portugal's Alentejo region. Treatments were triplicated, resulting in nine plots per site. The effect of the treatments in three different microenvironments of the plots (Tree, Rut, and Veg) were also assessed.

Preliminary results indicate that the mulch treatment reduced runoff peak flows by 11 % and the mulch+biochar treatment by 47 %, compared with the untreated soil. Both treatments increased soil moisture (between 5 to 15 %). The mulch treatment increased soil repellency, while the mulch+biochar treatment had no significant effects. Regarding microenvironments, soil moisture was lower in the Tree (plant/tree rows) and soil repellency was higher in the Rut (compacted region where the tractor wheels pass through). The mulch+biochar treatment performed best overall, highlighting the products complementary benefits in improving soil water balance, by reducing runoff losses and consequently increasing soil moisture.

KEYWORDS

sustainable agriculture; climate adaptation; soil degradation; desertification; hydrology; agroecosystem resilience.

REFERENCES

Note: Country of Wageningen University is the Netherlands and not Netherland Antilles, but the option was missing.



GT 05 - 168 - P

QUANTIFYING VEGETATION INTERCEPTION EFFECTS ON SOIL EROSION IN AGRICULTURAL AND URBAN CATCHMENTS

GT 05. SOIL HYDROLOGY & EROSION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Precipitation interception by vegetation is an important part of the water cycle in urban and agricultural areas. The intensity of soil erosion depends on the amount of precipitation intercepted by vegetation and the runoff generated by throughfall and stemflow. The question of how vegetation in agricultural and urban catchments influences precipitation interception, raindrop structure and velocity, and erosive power needs to be better understood.

These topics are closely linked to the objectives of the ongoing bilateral research project between the University of Ljubljana, Slovenian Forestry Institute and the Vienna University of Technology. The project focuses on understanding the impacts of meteorological and vegetation characteristics on the erosive power of precipitation in urban and agricultural areas. The drop diameter and velocity of raindrops below the vegetation, which reach the ground as throughfall from leaves and branches, differ from the diameter and velocity of raindrops above the canopy.

The high-resolution disdrometer measurements of open field precipitation and throughfall at three different study sites are presented, including urban park trees and urban mixed forest in Slovenia and a maize field in a small agricultural catchment (HOAL) in Austria. The collected data are used to determine and compare the distribution of raindrops and their changes under vegetation. For each study site, precipitation events were selected based on similar characteristics (i.e. precipitation amount, duration or intensity). Event based analysis considering 5-minute time steps was used to determine how different vegetation types influence changes in raindrop size and velocity of throughfall compared to raindrops in the open field.

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GT 05 - 429 - P

ANALYSIS AND MODELING OF THE HYDROLOGICAL RESPONSE OF EXTENSIVE GREEN ROOF LYSIMETERS

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Green roofs (GRs) are recognized as Nature-Based Solutions for the sustainable management of stormwaters in Mediterranean urban and peri-urban areas. They are engineered soil–vegetation systems installed atop anthropogenic structures, designed to deliver multiple environmental and hydrological benefits. In contrast to conventional impervious roofs, GRs effectively retain a portion of the stormwaters and gradually release it into the atmosphere through plant evapotranspiration, thereby attenuating and delaying the peak flow entering urban drainage systems over time. The hydrological performance of a GR is defined by its detention capacity, or the temporary storage of incoming stormwater, leading to a delay and reduction in peak flood discharge, and its retention capacity, or the permanent storage of stormwater, resulting in a reduction in the overall runoff volume. Both are conditioned by the hydraulic properties of the substrate and the interception capacity of the vegetation layer. This study aimed to quantitatively assess and model the hydrological response of ten distinct configurations of extensive GR lysimeters (each approximately 0.5 m² in surface area), exposed for three months to atmospheric agents on the roof of the Department of Agricultural, Food and Forest Sciences of University of Palermo, and equipped with automatic volume samplers for the measurement of drainage volumes. GRs performance was evaluated in terms of reduction of stormwater drained volumes and delay in peak flow. The effect of stormwater interception by vegetation was also considered. Rainfall data were recorded by a weather station located adjacent to the lysimeters. Four commercial substrates and a mixture of 80% sandy loam soil and 20% commercial compost were considered. The response of each substrate was analysed under two distinct conditions: i) vegetated with Sedum album (V), and ii) non-vegetated (NV). The hydraulic properties of the GR substrates, i.e., the water retention curve and the hydraulic conductivity function, were determined by a combination of the evaporation method (HYPROP system) and dew-point technique (WP4 device). Results showed that during the first month of observation, the drainage volumes from the V substrates following rainfall events were higher than those from the corresponding NV substrates. However, after one month, the trend was reversed, with each V substrate producing lower drainage volumes in comparison to its NV counterpart. This inversion is attributed to the establishment of the root system and the increase in vegetative cover within the test beds, as confirmed by aerial photogrammetry. The mixture of sandy loam soil and compost exhibited the most favourable hydrological response, resulting in the greatest reduction and delay in peak flow. Simulations of the drainage flows were finally conducted by the Hydrus-1D model to estimate the hydraulic response of the extensive GR lysimeters under different climatic conditions.



GT 05 - 433 - P

A COMPARISON OF THERMOGRAVIMETRIC, TDR, ERT, AND EMI METHODS FOR MONITORING SPATIAL AND TEMPORAL CHANGES IN WATER CONTENT ALONG A TRANSECT DURING AN INFILTRATION EXPERIMENT

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Monitoring and modeling soil hydrological processes at large scales require knowledge of how volumetric water content (θv) varies across space and time. While θv can be directly measured through soil sampling and laboratory analysis, such methods are labor-intensive and inefficient for capturing high-resolution spatial and temporal variability. Time-domain reflectometry (TDR) offers a field-based, indirect alternative by measuring the travel time of electromagnetic pulses in a probe to estimate θv. However, TDR remains a point-scale, invasive method that limits its applicability at larger scales or subsurface depths. To overcome these limitations, geophysical methods such as electrical resistivity tomography (ERT) and electromagnetic induction (EMI) are increasingly used due to their efficiency and broader spatial coverage. ERT involves inserting multiple electrodes into the soil and connecting them with cables to derive resistivity profiles, while EMI allows for rapid, non-invasive measurements without physical soil contact. Despite their advantages, ERT and EMI do not measure θv directly. Instead, they provide estimates of electrical resistivity (ρ) and bulk electrical conductivity (σb), respectively, from which θv must be estimated using inversion models and soil-specific relationships. These geophysical outputs must be further interpreted to map θv distributions accurately, requiring careful calibration. This study aims to compare thermogravimetric analysis, ERT, and EMI methods in their ability to monitor the spatio-temporal evolution of θv at the transect scale. Field experiments were conducted along a 25 m × 1 m transect in a sprinkler-irrigated agricultural area in Arborea, Sardinia, Italy. Data were collected through a series of measurement campaigns using auger and undisturbed samples, Campbell TDR-200 sensors, ERT, and a CMD mini-explorer EMI device. TDR measurements were used to establish empirical relationships between θv and σb. Inversion models then transformed the ERT and EMI measurements into σb distributions using prior soil profile characterization, including information on layering, texture, and depth to groundwater. The established TDR-based θv – σb relationship was then applied to the σb maps derived from EMI and ERT, enabling indirect estimation of σb across space and time. This integrated approach allowed for a comprehensive evaluation of the effectiveness and limitations of each method in characterizing soil moisture dynamics at field scale.

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GT 05 - 445 - P

A REGIONAL DATASET OF SOIL ERODIBILITY FOR THE SABOR RIVER BASIN, NE PORTUGAL: MAGNITUDE AND SPATIAL DISTRIBUTION

GT 05. SOIL HYDROLOGY & EROSION / GT 05. SOIL HYDROLOGY & EROSION

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Northeastern Portugal faces both natural and accelerated water erosion, which compromises land sustainability and productivity. Although recognized as a major threat to soil resources, erosion remains relatively misconsidered by regional actors. Improved assessments of erosion factors are basic for better designed strategies towards regional sustainable development.

This study aims at presenting an assessment exercise of soil erodibility in the Sabor River Basin (SRB, 3,310 km2), a major tributary of the Douro River in NE Portugal. The Universal Soil Loss Equation (USLE) erodibility factor (K) was calculated with data from 192 soil profiles described in the regional soil map. Soil Unit (SU) K value is the median of the set of profiles describing SU.

K spatial variability in SRB is represented by 121 map units (MU), which may include up to three SU, MU K values being weighted averages of their corresponding SU K values. K correction for surface rock fragments effect used USLE approach and a regional soil stoniness map produced by one of the authors.

Outcomes of this work were a reference dataset of K values at profile, SU, and MU levels, along with a soil erodibility map. In SRB, K averages 0.057±0.011 and 0.028±0.009 ton ha-1 (MJ ha-1 mm h-1)-1, respectively, for fine earth and stoniness corrected. These results reflect both the regional soils high susceptibility to erosion and the strong mitigating effect of rock fragments, widely present in SRB.

K variability, in SRB, averages 20% without and 32% with stoniness correction, highlighting soil heterogeneity across the basin, an aspect not captured in the European Soil Data Centre (ESDAC) dataset. Compared to ESDAC, this study refines continental-scale resolution, correcting underestimations of 26% for average erodibility and 29% for stoniness corrected.

The dominant SU in SRB is the Ortho-Dystric Leptosol developed on schist, covering 32.34% of the area, with K factors of 0.061 and 0.033 for fine earth and stoniness corrected, respectively. Texture and organic matter are the main contributors to SU erodibility (78% ± 19%), followed by structure (12% ± 8%) and permeability (10% ± 5%), confirming the strong influence of the first component.

The generated dataset integrates quantitative, qualitative, and spatial elements, supporting more robust erosion risk assessments and improved land management strategies in SRB.

ACKNOWLEDGEMENTS

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GT 05 - 527 - P

ASSESSING METAL TRANSPORT IN THE MINING DISTRICT OF LA UNIÓN-SIERRA DE CARTAGENA (SE SPAIN): A USE-CASE OF THE SOILPROM PROJECT

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The Horizon Europe project SOILPROM aims to deliver upgraded and integrated models for pollutant transport and fate to evaluate the impact of soil pollution on soil functions and related ecosystem services. The project supports local stakeholders in developing sustainable land management strategies and policies to promote healthy soils across Europe. SOILPROM addresses five major pollutant categories (metals, microplastics, PFAS, pesticides, and nutrients) and examines key environmental processes driving pollutant transport, transformation and fate in soil systems through seven use-cases distributed across The Netherlands, Germany, Belgium, Spain, Poland, and Norway.

One of the use-cases is located in the La Unión-Sierra de Cartagena mining district (SE Spain), a Mediterranean semiarid region heavily degraded by historical metal mining. This area is impacted by high levels of potentially toxic metals and metalloids (e.g., Pb, Zn, Cd, As) and is highly vulnerable to both intense wind and water erosion. In this context, two key soil processes governing metal dispersion are under study: (i) hydrological transport via hydric erosion, and (ii) atmospheric dispersion via wind erosion. Fieldwork is being conducted along El Beal wadi, an ephemeral stream channel draining the mining area toward the Mar Menor lagoon, the largest coastal lagoon in the Mediterranean basin. The El Beal wadi's bed, largely composed of metalliferous mine tailings, has historically served as a major metal transport pathway. To evaluate hydric erosion, studies will focus on the head of the watercourse, assessing sediment retention (using erosion nails and drone-based photogrammetry) within a series of dams built in the waterbed to mitigate pollution dispersion. Sediment samples will be collected after erosive storm events (from summer 2025 to autumn 2026) and analyzed for metal/metalloid content, particle size, pH and electrical conductivity. The OpenLISEM model will simulate water runoff, infiltration and erosion-driven metal transport. For wind erosion, work will focus on a flat area located near the watercourse mouth, which is affected by strong summer winds. Dust catchers will be installed to capture airborne particles at different heights during the driest and windiest months for two years (summer 2025 and 2026) and analyzed for metal/metalloid content, particle size, and pH. The MicroHH model will be used to simulate the transport and deposition of metal-laden dust.

This integrated assessment will provide valuable insights into metal behavior in polluted soils, supporting the development of sustainable remediation strategies in semiarid mining-impacted environments.

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GT 05 - 583 - P

SOIL WATER RETENTION CURVE USING A DIELECTRIC PERMITTIVITY REGRESSION

GT 05. SOIL HYDROLOGY & EROSION / GT 02. SOIL PHYSICAL CHEMISTRY

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The monitoring and understanding of the movement of water through soil has broad applications not limited to irrigation and food security, flood risk, landslide risk assessment, wildfire risk management, and many other applications relating to water resources.

The Richards Equation has become one of the most common ways to describe and quantify the transient movement of water in unsaturated porous media. The Richards Equation contains the unsaturated hydraulic conductivity parameter. The unsaturated hydraulic conductivity is important for both physically based models, such as HYDRUS, and for machine learning statistical-based models to predict soil moisture. Hydraulic conductivity is determined from a water retention curve, which is a plot of soil moisture versus unsaturated hydraulic head. The numerical solution for the unsaturated hydraulic conductivity from the water retention curve is the van Genuchten equation. The water retention curve, however, is often difficult to obtain in the laboratory and difficult to apply to soil moisture data in the field.

A new fixture called The Travel Assembly has been developed to hold a soil sensor in a soil sample during the laboratory development of a soil water retention curve. The Travel Assembly consists of a soil core sample in a metal ring of known volume, an SDI-12 HydraProbe soil sensor, and a mesh on the bottom holding the soil sample in place while allowing the exchange of water in and out of the sample. The Travel Assembly can be placed on low-tension hanging water column tables and in pressure extractors that can be pressurized up to 1500 kPa. For saturation, the Travel Assembly can be placed in a Tempe Cell.

The dielectric permittivity, which is the raw electrical parameter used for soil moisture determination, is measured at every pressure condition. The resulting soil water retention curve consists of soil moisture determined gravimetrically, pressure, and the dielectric response from the HydraProbe Soil Sensor. Upon completion of the soil water retention curve, HydraProbes in the field in the same soil tested are able to measure soil moisture very accurately with a custom calibration and unsaturated hydraulic head.

Six soil samples, a Columbia silt loam alfisol, were placed in the Travel Assembly and evaluated at saturation and 10 pressures ranging from 0.01 to 5 Bar. The technique was perfected to generate a soil water retention curve with minimal error.

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GT 05 - 638 - P

AN EXPERIMENTAL APPROACH TO EROSION THROUGH SOIL SURFACE CHARACTERISTICS DYNAMICS: A CASE STUDY IN THE CLAY-LIMESTONE HILLY LANDSCAPES OF SOUTHWEST FRANCE.

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil erosion is a natural process that is often exacerbated by anthropogenic activities such as farming. Croplands, where soils may be bare during intercropping periods, are particularly exposed to this hazard. To prevent erosive events, we need to identify sensitive areas. Modelling can be a valuable tool that can help address these issues, provided that the models used are adapted and contextualised to the specific conditions of the study areas.

Because erosion is mainly water-related, it is closely linked to the study of runoff dynamics on slopes. This is the main approach to modelling erosion: first simulating runoff and then coupling soil losses to this runoff. Various modelling procedures are used to simulate runoff: empirical methods, mechanistic methods, expert-based decision rules, etc. The experimental approach presented in this study aims to explore runoff and erosion by monitoring soil surface characteristics over a full year.

This study takes place in the Montoussé catchment area (Auradé, France), located in southwest France. Covering 328ha and exposed to a high erosion risk, this watershed has been instrumented since 1982 and offers a rich dataset.

Soil surface characteristics are surveyed over a year at monthly time steps in multiple locations within the catchment. Three variables are systematically recorded: the soil surface crusting, the roughness and the crop cover. Sampling sites were selected based on homogeneous cartographic units, each defined by a unique combination of three influencing factors: slope and aspect, frequency of bare soil in crop rotations, and soil type. Each unit is represented by 3 observation points.

Although soil surface dynamics have been widely studied, the main literature focuses on silty soils. The experiment presented here should therefore provide information on the evolution of soil surface characteristics in clay-limestone soils, for which there is a lack of knowledge. This advancement will contribute to parameterising a soil erosion model (WaterSed) for the specific case of hilly landscapes with clay-limestone soils. Additionally, the study should highlight certain features unique to clay-limestone areas, which could play a significant role in erosion processes. These include the temporal dynamics of soil shrinkage and the presence of millimetric particles, so-called “pseudosand”, which have been observed on crusted surfaces.

GT 05 - 736 - P

EFFECTS OF DIGESTATE PARTICLE SIZE AND DEPTH APPLICATION ON SOIL EROSION UNDER SIMULATED RAINFALL CONDITIONS

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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An increasing number of studies have focused on the use of digestate in agriculture as an organic amendment, but relatively few have examined its effects as a soil improver for the restoration of degraded soils (e.g., burned forest areas, road slopes, and quarries). In general, agronomic studies concentrate on evaluating its effectiveness as an amendment and comparing it with other organic products such as compost, biochar, and sewage sludge, in terms of their impact on the physical, chemical, and biological properties of the soil.

Forestry or environmental applications of digestate are uncommon, and its benefits to soil in such contexts are not well documented. Furthermore, the influence of digestate placement within the soil and its particle size has not been thoroughly investigated. Studies conducted in agriculture using biochar or compost indicate that the depth of application and particle size are relevant to the soil’s hydrological and physicochemical behaviour.

For this reason, the Ecoloop project has recognised the need for research into the potential use of digestate in the forestry sector, with the aim of determining whether its application (considering both depth and particle size) can affect soil physical properties and, consequently, its response to erosion. To this end, a laboratory test was designed to apply an amount of digestate sufficient to increase the organic matter content of the soil by 2%. Two application methods were compared: surface application (as mulch) and incorporation into the topsoil (0–10 cm). Two particle size ranges of digestate (2–0.1 mm and 0.1–0.002 mm) were used. The soil consisted of a mix of mineral materials from a limestone quarry and degraded soil with an organic matter content of less than 0.65%.

The hydrological behaviour and erosion potential were evaluated through rainfall simulation tests. Steel trays (75 × 68 × 10 cm) were filled with the corresponding digestate-soil mixtures. Simulated rainfall was applied at an intensity of approximately 60 mm h^{-1} for 30 minutes. The trays were set at a 9% slope. A factorial design of 2 application methods × 2 particle sizes × 3 replicates, plus 3 control (blank) samples, was used, resulting in 15 distinct experimental units.

In conclusion, the application of digestate to soil led to significant improvements across all treatment combinations compared to the control. These improvements included reduced soil erosion and increased permeability, which delayed runoff onset and enhanced water infiltration, both of which contribute to an improved hydrological response.

ACKNOWLEDGEMENTS

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GT 05 - 762 - P

MULCH AND BIOCHAR AS TOOLS FOR SOIL CONSERVATION: EFFECTS ON EROSION CONTROL AND CARBON RETENTION IN AGROECOSYSTEMS

GT 05. SOIL HYDROLOGY & EROSION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil is a vital component of terrestrial ecosystems, playing a fundamental role in supporting life and regulating the Earth's climate. However, increasing anthropogenic pressures have intensified soil degradation, resulting in severe consequences, including erosion and desertification. This highlights the urgent need for effective soil conservation and restoration strategies.

This study evaluated the effectiveness of mulch (2 t ha-1) and mulch+biochar (2 + 10 t ha-1) on erosion control and carbon retention in three agroecosystems in Portugal: vineyards, olive orchards, and cork oak woodlands (montado or dehesa). Each area was subjected to three treatments-control, mulch (M) and mulch+biochar (MB), replicated in three sites per area. Wheat straw mulch was applied in vineyards and montado and olive leaves in olive orchards. Sediment fences were installed at the base of hillslope plots to collect sediments and filter runoff. Sediments were weighed in the field, sampled and sieved to separate the sediment (<2 mm) from coarser fractions. Organic matter and carbon content were analysed in the fine sediments.

Results showed consistent erosion reduction wherever treatments were applied. The most severe case was in a steep olive orchard, with 2.2 Mg ha-1 of fine sediment lost over 15 months. Mulch reduced erosion by 29.2%, while the MB achieved 35.6%. The highest efficacy occurred in a vineyard with lower soil stoniness, where control plots produced 0.44 Mg ha^{-1} of sediments, and M and MB reduced erosion by 62-65%. Montado systems, with minimal disturbance, had lower control losses (0.31 Mg ha^{-1}), and M and MB treatments reduced erosion by 86.9% and 72.2%, respectively. Carbon losses followed erosion patterns, peaking in intensively managed orchards with low stone content. Losses reached 0.7 Mg ha-1 in the steep olive orchard, but overall, M and MB reduced carbon losses across all systems.

These findings highlight the potential of using organic soil amendments, particularly mulch and biochar, as effective tools for mitigating soil erosion and carbon depletion, especially in intensively managed agricultural systems. The adoption of such conservation practices is essential to preserving soil health, maintaining ecosystem services, and support climate change mitigation efforts.

KEYWORDS

soil restoration, desertification, climatic changes, carbon sequestration.

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GT 05 - 785 - P

EFFECT OF BIOCHAR ON SOIL HYDRAULIC PROPERTIES: INFLUENCE OF APPLICATION RATE AND PARTICLE SIZE

GT 05. SOIL HYDROLOGY & EROSION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The incorporation of biochar into soils presents a promising strategy for achieving carbon sequestration and enhancing climate resilience by improving water retention in sandy soils and aeration in finer-textured soils. However, the effectiveness of biochar addition can vary significantly based on particle size and application rate, complicating the establishment of optimal soil management practices. Here, we present a detailed investigation on how biochar addition influences the soil hydraulic properties of a sandy soil. Water retention and hydraulic conductivity curves were determined across the full moisture range on packed soil samples. Measurements with the simplified evaporation method were complemented by direct assessments of saturated hydraulic conductivity and water retention in dry soil by the dew point method. Biochar application rates ranged from 0 % to 4 % by mass across three different particle sizes, ranging from < 0.5 mm to < 10 mm. We fitted a comprehensive model of soil hydraulic functions to all measured data, accounting for water adsorption and film flow. Our findings highlight the impact of biochar on soil hydraulic conductivity, water retention and bulk density, with effects being more sensitive to application rate than to particle size.



GT 05 - 795 - P

NEW CLASSIFICATION OF SOIL TEXTURE FOR LASER DIFFRACTION METHOD

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Modern studies show that determining the texture class of soils according to Kachinsky (Russian classification) and USDA/FAO using texture data obtained using the laser diffraction method leads to an error of 43% and 65%, respectively [1]. This problem arises because existing classifications were developed based on sedimentation methods. Although laser diffraction and sedimentation methods provide information on particle size and correlate with each other, they are based on different physical principles. Attempts to use conversion models between methods for measuring particle size distribution have also not been successful.

The goal of the project is to develop a new classification of soil texture for the laser diffraction method.

The main reference in the new classification is the mechanical behavior of the soil (plasticity and fluidity limits, plasticity number), as well as the measurement of the texture class determined by field methods. The project involved crowdsourcing work to collect a collection of samples (3,131 pcs.) that differ in sampling location, texture classes, organic carbon content, and soil types. The plasticity and fluidity limits, particle size distribution, and laser diffraction measurements were used to measure the samples in the collection, and the texture classes were determined using the cord method (Kaczynski method) and the ball and tape method (FAO/USDA method). Based on the data, new boundaries for silt and sand fractions were found for the laser diffraction method. Based on the new fraction boundaries, classification principles were developed and silt and sand content ranges were identified for FAO/USDA fractions and for fractions according to the Russian classification. An ML model was developed for calculating the fluidity limit and plasticity limit based on the parameters of the particle size distribution approximation obtained for laser diffraction. The result of the project work was the development of a new classification of soil texture for the laser diffraction method, which will allow for reliable interpretation of measurement data.

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GT 05 - 873 - P

USING VIS-NIR SPECTROSCOPY TO TRACK SOIL MOISTURE DYNAMICS IN BARE-SOIL EVAPORATION EXPERIMENTS

GT 05. SOIL HYDROLOGY & EROSION / GT 09. SOIL HEALTH

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Understanding the relationship between soil moisture and spectral characteristics is essential for developing remote sensing methods to monitor soil water dynamics. Spectroscopy offers a non-invasive approach to estimate surface moisture, but its ability to track real-time changes under natural drying conditions remains insufficiently explored.

The link between soil moisture and spectral responses was usually investigated by analyzing soil samples with predefined moisture levels to build calibration models. It is still unclear whether spectral methods can effectively capture real-time changes in surface moisture during the drying process. To investigate this, we carried out evaporation experiments using compacted soil columns (5 cm high) filled with two soil types: sand and silt loam. Surface moisture content was monitored by repeatedly measuring reflectance spectra across the visible, near-infrared, and shortwave infrared ranges (350–2500 nm) using an ASD Fieldspec® Pro spectrometer. Subsequently, spectrally derived water contents were compared against results from numerical simulations (HYDRUS-1D) based on the Richards equation, which contained soil hydraulic parameters obtained via the simplified evaporation method and used actual evaporation rates as boundary conditions.

Separate sets of soil samples with known moisture contents were used to build a predition model. Linear regression, principal component regression (PCR) and partial-least-squares regression (PLSR) were used for model development. Based on AICc and RMSE of cross-validation polynomial linear regression produced the most accurate results. In the dynamic evaporation experiments, the spectral model generally underestimated surface water content relative to the Richards-based simulations. While predictions for the silt loam were relatively accurate (mean error: 2.81 vol%), moisture levels in the sandy soil were consistently underestimated (mean error: 7.13 vol%), which may be attributed to measurement conditions or the positioning of the contact probe.

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GT 05 - 881 - P

MECHANISMS OF SOIL EROSION: PROCESSES AND LANDFORMS IN THE EL-HARRAR WATERSHED

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Water erosion is a major environmental threat, particularly in arid and semi-arid regions, where fragile ecosystems are highly vulnerable to soil degradation. While erosion results from natural processes, its intensity has markedly increased due to unsustainable land use and anthropogenic pressures. These dynamics lead to various forms of land degradation, whose severity depends on the physical fragility of the landscape.

The El Harrar watershed, located in the eastern Pre-Rif hills of Morocco, spans approximately 89 km² and constitutes a tributary of the Lahdar basin. This area displays intense erosion activity driven by steep slopes, a highly incised drainage network, fragile lithology dominated by clayey formations, shallow and weakly developed soils, and degraded vegetation cover. The arid climate, marked by irregular and erosive rainfall, further exacerbates land instability.

This study aims to identify and characterize the dominant forms and processes of water erosion in the watershed through aerial photo interpretation complemented by targeted field validation. The objective is to map critical erosion-prone areas to support soil conservation strategies and guide land management policies in vulnerable Mediterranean landscapes.

KEYWORDS

Morocco, water erosion, landform dynamics, El Harrar watershed.

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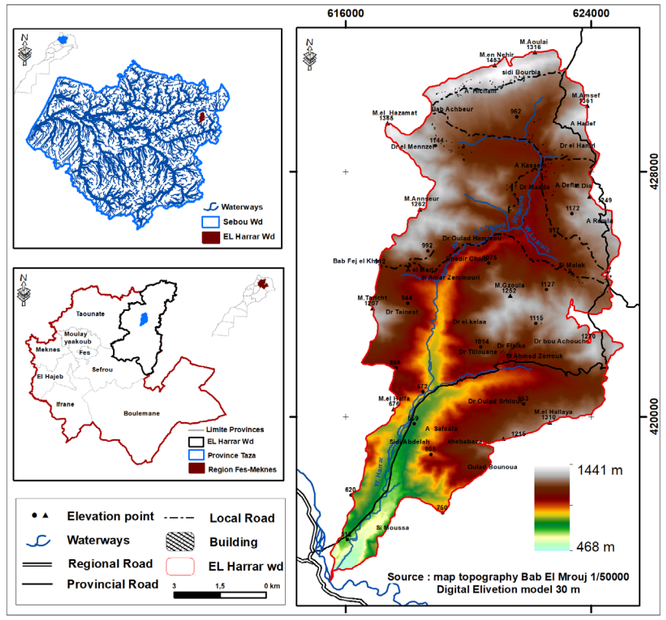


Fig. 1- Localisation of stady area the EL Harrar watershed



GT 05 - 891 - P

THE CHARACTERISTICS OF SOIL SPLASH PHENOMENON IN RELATION TO THE POTENTIAL MICROORGANISMS TRANSPORTATION

GT 05. SOIL HYDROLOGY & EROSION / GT 04. SOIL BIOLOGY

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As a natural outer layer of the lithosphere and an important component of many ecosystems, soil may be subjected to various degradation processes. One form of physical soil degradation is water erosion, the initial stage of which is the splash phenomenon caused by raindrops hitting the soil surface. This process results in the detachment and ejection of soil material over different distances, which leads to loss of material, breakdown of soil aggregates and changes to surface microstructure. However, this phenomenon may also be related to the transport of soil microorganisms that are displaced together with splashed particles, which is an important issue in case of agricultural and health aspects.

The aim of this study was to present the aspects of the soil splash phenomenon that may be important in context of the potential microorganisms transportation. The study was based on the demonstration of methods used at the Institute of Agrophysics PAS to investigate soil splash - these include among others: a) a set of high-speed cameras combined with PTV module (Particle Tracking Velocimetry) used to determine the number of splashed particles and to identify, track, and characterize the particles and water droplets; b) splash cup measurements used for the calculation of the mass ratio of splashed particles (including the division into solid and liquid phases); c) a 3D surface scanner for the description of soil deformation after the drop impact; d) a laser diffraction method and light microscopy for the determination of the size of splashed particles; e) piezoelectric sensor to measure the kinetic energy of impacting drop.

ACKNOWLEDGEMENTS

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GT 05 - 898 - P

RESTORATION POTENTIAL OF INOCULATED BIOCRUSTS: EFFECTS ON EROSION AND NUTRIENT EXPORT IN DRYLANDS

GT 05. SOIL HYDROLOGY & EROSION / GT 05. SOIL HYDROLOGY & EROSION

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Biological soil crusts (biocrusts) are key components of dryland ecosystems, where they stabilize surface soils, regulate nutrient dynamics and modulate hydrological and erosion processes. Composed primarily of autotrophic and heterotrophic organisms in close association with soil surface particles, these communities are sensitive to disturbance. Despite recent advances in strategies to restore biocrusts in degraded environments, the functional impact of newly induced biocrusts on critical ecosystem processes, such as soil and nutrient retention, remains poorly understood.

This study investigates the effects of biocrust removal, unaltered biocrusts and induced biocrust by cyanobacterial inoculation, runoff, soil erosion, and nutrient export under field conditions. Experimental plots were established in the Tabernas Desert (SE Spain), a semiarid badlands area, where biocrusts cover over 40% of the surface, playing a key role in ecosystem functioning. From October 2024 onward, we monitored runoff, and soil and nutrient losses on three types of soil covers: (1) undisturbed biocrusts dominated by lichens and cyanobacteria (control), (2) biocrust-removed plots simulating soil disturbance, and (3) biocrust-removed plots subsequently inoculated with native cyanobacteria to emulate early-stage biocrust recovery. After each rainfall event, runoff water was collected, and exported sediments, and organic carbon (OC) and nitrogen (N) content in sediments were quantified.

Results reveal a clear gradient between treatments: erosion along with organic carbon (OC) and nitrogen (N) export associated with sediments, were highest in biocrust-removed plots, followed by inoculated plots, and lowest in undisturbed controls. Compared to control plots, OC export in removed plots were approximately1.7 times higher, and nitrogen export nearly 2.8 times greater. Interestingly, inoculated plots exhibited about 35% lower OC export and 26% lower nitrogen losses than the fully disturbed (biocrust-removed) plots, along with 40% lower erosion.

Undisturbed control plots not only showed minimal erosion but also the highest concentrations of OC and N in the collected sediments. However, due to their low erosion rates, total nutrient losses were the lowest, highlighting the stabilizing and nutrient- retaining role of intact biocrusts. These findings underscore the effectiveness of cyanobacterial inoculation as a promising strategy to enhance soil stability and nutrient retention in degraded arid ecosystems.

ACKNOWLEDGEMENTS

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GT 05 - 940 - P

UAV-BASED MONITORING OF SOIL EROSION IN MEDITERRANEAN AGRICULTURAL ORCHARDS UNDER LOW EROSION RATES

GT 05. SOIL HYDROLOGY & EROSION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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As soil erosion is one of the main causes of land degradation in the Mediterranean, high-resolution spatial information on soil erosion is important for soil conservation. UAV imagery has become an important instrument for erosion monitoring but little is known about its application in Mediterranean agricultural systems. In this study, drone flights were conducted in vineyards and olive groves where soil conservation measures were applied. Digital Terrain Models (DTM) and orthomosaics were constructed with a photogrammetry workflow, from which topographic variables were derived. Erosion was assessed both by field erosion plots and through Digital elevation models of Difference (DoD).

Differences between treatments and relations between topographic variables and erosion were investigated with statistical analysis. As erosion rates during the study period were low, the DoDs did not detect any erosion. Significant differences in DTM-derived variables were found between study areas, but not between treatments. The results suggest that soil erosion in the study areas is mostly determined by topographic and management factors, and not by the applied treatments. This study

shows that UAV imagery can contribute to erosion monitoring in Mediterranean agricultural systems, but that determining net erosion from DoDs at low erosion rates remains a challenge.

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GT 05 - 990 - P

THE INFLUENCE OF SOIL ORGANIC MATTER ON SOIL ERODIBILITY (K-FACTOR) IN ALPINE SOILS

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Understanding soil erodibility (K-factor of USLE – Universal Soil Loss Equation) drivers in mountain environments is particularly challenging due to the complex interplay among the soil forming factors and human-driven processes (e.g. land use change). This complexity is particularly evident in an alpine region such as the Aosta Valley (NW Italian Alps), where the degree of pedodiversity is very high [1]. Building on existing soil data and knowledge, we compiled a soil database covering the whole region (n=308), and computed topsoil erodibility (K factor) using two empirically derived formulas: USLE [2] and EPIC [3], both incorporating soil organic matter (SOM) content. For the USLE formula, a stoniness correction factor was applied to account for the influence of surface coarse fragments on soil erodibility, and a higher SOM threshold (9%) was also tested to better capture the elevated organic matter contents typical of mountain soils. We focused on the statistical analysis of point-based field data, including soil-related variables (such as humus system, soil type, soil horizon, and land use). These inputs were analyzed to assess their relationship with K values and better understand how these variables relate to erosion vulnerability. Our results showed that (i) the USLE K equation seems to more effectively capture the complexity of mountain environments compared to EPIC; (ii) SOM - particularly its content and type - emerges as a key factor reducing soil erodibility in our study area, with additional effects related to stone cover and maximum SOM thresholds to be used in the formula (iii) K values vary significantly across different soil horizons, humus systems, land uses and soil types. These findings underscore the central role of SOM in enhancing soil stability in alpine environments and demonstrate how specific land covers and pedological features can be associated with the degree of vulnerability to erosion. This knowledge will provide a basis for spatial prediction of erosion-prone areas, offering valuable support for the development of targeted soil monitoring, conservation, and restoration strategies in mountain landscapes.

KEYWORDS

mountain, USLE, erosion, land use, pedological features

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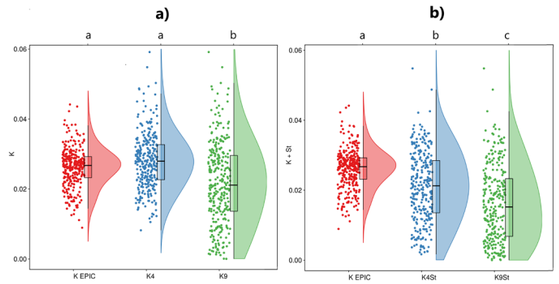
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Soil erodibility (K) estimated using the Williams et al. (1983) equation (KEPIC, 305 samples) and the Wischmeier and Smith (1978) equation (K4 with 4% SOM threshold and K9 with 9% SOM threshold) without including the Stoniness factor (St). b) Same calculation as a but including the Stoniness Factor (St) for K4 and K9.



Soil erodibility (K) estimation methods comparision



GT 05 - 1005 - P

IMPACT-EROSION, A TOOLBOX TO DEMOCRATIZE SOIL EROSION MODELLING

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The assessment and mitigation of soil erosion are critical for sustainable land management and environmental protection. However, the application of soil erosion models is often hindered by their complexity, requiring significant user expertise and computational resources. This can limit their use by educators, researchers, and local-scale land managers. To address this challenge, we introduce iMPACT-erosion, a novel, open-source toolbox designed to make soil erosion modelling more accessible, interactive, and educational.

iMPACT-erosion leverages the power of Python and Jupyter Notebooks to provide a user-friendly, learn-by-doing environment that requires no local software installation. The toolbox is structured into three distinct modules: iMPACT-Start, which guides users through foundational tasks such as data preparation and catchment delineation; iMPACT-Test, which focuses on model calibration, validation, and sensitivity analysis; and iMPACT-Explore, which enables the simulation of different land management scenarios to evaluate the effectiveness of mitigation strategies.

By integrating explanatory text, interactive maps and charts, and editable code cells, iMPACT-erosion empowers users of all experience levels—from novices to experts—to engage directly with modelling concepts and workflows. This approach not only facilitates a deeper understanding of soil erosion processes but also promotes transparent and reproducible research. The iMPACT-erosion toolbox represents a significant step towards the democratization of soil erosion modelling, fostering a broader application of scientific tools to address pressing environmental challenges.

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GT 05 - 1006 - P

AUTOMATIC DETECTION OF EPHEMERAL GULLIES IN WALLONIA (BELGIUM) USING REMOTE SENSING : A PIXEL-BASED APPROACH AND COMPARISON WITH MULTIRESOLUTION SEGMENTATION

GT 05. SOIL HYDROLOGY & EROSION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Gully erosion is a significant soil erosion process with potentially severe on-site and off-site impacts. Its consequences range from reduced crop yields to compromised building stability in urban areas. They also increase the sediment connectivity in watersheds, contributing to muddy floods during strong storm events.

Characterizing and monitoring gullies is essential for accurately predicting their occurrence and effectively preventing their formation and extension. However, creating a gully inventory is both time-consuming and subject to operator bias. This remains one of the main obstacles to effective monitoring and the development of accurate prediction models. Given the low spatial density of gullies in most contexts, the use of remote sensing to map gully erosion appears unavoidable, but it faces multiple challenges.

In Wallonia (Belgium), gullies occur mainly as ephemeral gullies on agricultural land and are mostly formed on bare or weakly covered soil. Depending on the time of the year they form, their width ranges from 50 cm to more than 3m. These dimensions imply that aerial imagery with at least 50 cm resolution are required to detect gullies. The high cost associated with acquiring such imagery at a regional scale remains a significant obstacle. Currently, the highest resolution freely available aerial images covering Wallonia are orthophotos (25 cm resolution since 2009). However, they are acquired on a yearly basis only and their acquisition period may not coincide with the timing of gully formation. Hence, gullies may be surrounded by bare or vegetated soil.

As of today, no methodology for automatically detecting gully erosion with such dimensions at regional scale appears to have been developed. This study aims at developing a methodology for automatically detecting ephemeral gullies in Wallonia by remote sensing.

A database of 168 gullies has been created, covering more than 1200 km² of Wallonia for the years 2019 and 2022. From this database, a set of gullies occurring on plots with different levels of soil cover (including bare soil) were selected. Orthophotos were clipped according to the field plot in which each gully was located. The Normalized Difference Vegetation index (NDVI) was computed for each plot and for the vegetation surrounding the gullies. A comparison between a multiresolution segmentation and a pixel-based approach to detect gullies was performed. Required spectral bands are red, green, blue, and near-infrared, along with NDVI.

Preliminary results show the pixel-based approach to be more efficient at detecting gullies down to an average NDVI value of 0,1 for the surrounding. Challenge remains in detecting gullies on bare soil. However, additional data such as a digital surface model derived from the orthophotos are being investigated for use as input during the segmentation process. In conclusion, this method shows potential for large-scale monitoring of gully erosion.



GT 05 - 1053 - P

PERFORMANCE OF OLIVE POMACE-BASED COMPOST AND BIOCHAR IN REDUCING EROSION RATES UNDER SIMULATED RAINFALL

GT 05. SOIL HYDROLOGY & EROSION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Weak soil aggregation associated with low organic matter is a common feature in Mediterranean agri-environments, namely in olive groves, where a high potential erosion risk prevails. Improving soil organic content is a conservation goal for such environments. Application of composts and biochar contributes to this goal, their single or combined effectiveness as soil conditioners being, however, still poorly known. The use of olive pomace for composts and biochar elaboration is also an on-going research challenge. This research aimed at assessing erosion control performance of a compost and a phosphate-enriched biochar elaborated using olive pomace as raw material. The experimental design comprised control (non-treated soil) plus 6 treatments: compost, P-biochar and their 50:50 mixture, all with 10 and 20 Mg ha-1 application rates. Biochar was produced in an industrial pyrolysis plant using olive pomace collected in a 2-phase olive oil factory and later enriched with phosphate. Compost was produced in 25 m3 piles, using the same olive pomace as biochar. A weakly aggregated, low organic matter, loamy Eutric Leptosol was sampled in an olive grove in Mirandela, NE Portugal. The <2 mm soil fraction filled-in bottom perforated plastic boxes (310 cm2 area, 5.5 cm depth), topped by the soil conditioners. Each simulation run consisted of a 30 min shower over 3 boxes, replicating a treatment, at 76 mm h-1 intensity. Boxes, leaning at 15% slope gradient, were equipped with a front edge runoff and wash collector, and a lateral splash board. Runoff water was sampled for P determination. In control, runoff was 24 mm, wash 345 g m-2, splash 455 g m-2, and P-concentration in runoff insignificant. In treated soil, wash and splash were significantly lower than in control, but not for runoff. The best performing treatment was compost at 20 Mg ha-1, yielding 57% of runoff, 21% of wash and 25% of splash measured in control and a low P-concentration in runoff (0.026 mg PO43-L-1). Compost treatments performed better in erosion control than biochar or in mixtures. For biochar, the lower application rate performed better in reducing soil loss, but not P-concentration in runoff, while the opposite was found for treatments with compost and mixtures, highlighting that compost helps biochar effects in controlling soil loss and P export. Results point out relevant effects of olive pomace-based soil conditioners in reducing erosion and P wash rates in weakly aggregated soils, typical of Mediterranean agri-environments, while valorizing a by-product of the olive oil production chain.

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GT 05 - 1063 - P

MODELLING THE IMPACT OF REGENERATIVE AGRICULTURE ON SOIL EROSION AND RIVER WATER QUALITY

GT 05. SOIL HYDROLOGY & EROSION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Current UK policy encourages water companies and farmers to collaborate and uptake minimum tillage and cover crops to reduce soil erosion's impact on the environment, field productivity, and raw drinking water quality. The aim of this study is to further improve the functionality of the modified Morgan-Morgan-Finney (mMMF) model as a decision support tool for water companies and land managers to target management options to reduce runoff and control soil erosion on farm to improve water quality. The objectives are to measure the key catch/cover crop and soil surface roughness parameters, reflect the inter- and intra-annual variability of soil erosion risk, identify flow paths and sediment discharge points, evaluate the model's improvements, and validate its predictions. Crop and soil surface roughness parameters are measured in fields under typical rotations thanks to ArcGIS, Python, and advice from seed suppliers and catchment advisors. Crop parameters are obtained using photo analysis, manual measurements in quadrats, and literature values, while the chain method is used to measure soil surface roughness. Inter- and intra- annual variability of soil erosion risk will be possible by modifying the mMMF's temporal resolution. Incorporating a connectivity module based on a routing function will help identify flow paths and sediment discharge points. Critical evaluation and validation of the improved model will be based on water quality and remote sensing data. The improved model could be used as a user-friendly tool by land managers, water companies, and the government to monitor soil health and river water quality but also to encourage collaboration between farmers and water companies. It could also be tested to predict the impact of catch/cover crops and minimum tillage on soil erosion risk in a wider range of crop rotations.

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GT 05 - 1078 - P

LANDSCAPE-SOIL-WATER RELATIONSHIPS: EVALUATING THE CONSERVATION USE POTENTIAL FRAMEWORK AND SOIL CARBON DYNAMICS IN WATERSHED TO SUPPORT SUSTAINABLE AGRICULTURAL PRODUCTIVITY.

GT 05. SOIL HYDROLOGY & EROSION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Evaluating conservation soil use potential and soil carbon dynamics in a watershed supports sustainable agriculture by guiding land-use practices that prevent degradation, enhance fertility, and store carbon. The concept of The Conservation Use Potential framework (PUC - Portuguese) shows the capacity of a soil to sustain certain activities without developing significant degradation processes. This study aimed to describe the PUC method and based on the potential for water recharge, carbon dynamics and agricultural use. The methodology was based on Saaty's (1997) Analytic Hierarchy Process (AHP) and Costa et al. (2017) work, developed in a multi-criteria decision-making method in an area of 563km2 at the Rico Stream Watershed (RSW), State of Sao Paulo, Brazil, into a hierarchy and in pairwise comparisons and priority scales to quantify, enabling consistent evaluation in a cartographically map algebra and zonal evaluations. The area is responsible for 75% of the public water supply and has faced problems as water stress and soil degradation. The mapping of PUC was prepared from the components soil, lithology and slope, which, respectively, were ranked according to (1) drainage, fertility, texture and effective depth; (2) chemical and mineralogical composition and susceptibility to denudation; (3) agricultural suitability criterion. The map algebra was according to Equation: PUC = (slope*0.50) + (soils*0.39) + (lithology*0.11), explained each percentegae of soil use potential. The data was obtained from São Paulo support land conservation analysis and the Soil Organic Carbon Stock (SOC) 1985-2021 was modeled by MapBiomas Soil and machine learning. The spatial overlap showed the regions of the priority areas, which were identified by their synergies in the classes between the PUC, land uses and SOC. The PUC indicates the susceptibility of a soil to offer better conditions for use (Fig 1). Areas with Very Low and Low PUC should be considered priorities for soil protection, considered Priority Conservation Zones and with high potential for ecological restoration. Understanding Landscape-Soil-Water relationships through the conservation use potential framework and soil carbon dynamics is vital for sustainable agriculture in watershed areas. The regionalization of these areas can serve as pilot programs to support Payment for Environmental Services (PES) schemes (Moura et al. 2024) by targeting areas with high ecological value. The main hydrological regions was upstream of the Rico Stream Watershed (RSW), and water source area. This approach supports informed decision-making for sustainable land and water use management and environmental planning.

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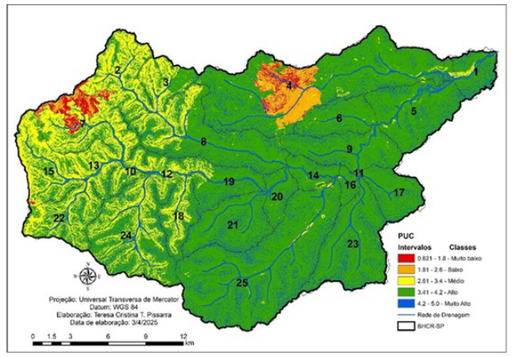


Fig. 1 Conservation Use Potential (PUC) map. Areas in a watershed according to their suitability or priority for conservation efforts, with color gradients indicating different levels of PCU values—from red (low) to blue (high).

GT 05 - 1092 - P

HYDROLOGIC SOIL TYPES OF NORTHERN, NORTHEASTERN, AND CENTRAL INLAND, PORTUGAL

GT 05. SOIL HYDROLOGY & EROSION / GT 05. SOIL HYDROLOGY & EROSION

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In Portugal, a growing intensification of hydrological extremes has been observed, manifesting differently across the territory: the northern region has been recurrently affected by flood events, while the central inland faces drought conditions, which significantly contribute to the advancement of desertification processes. Understanding the hydrological behaviour of soils, given their regulatory role in the hydrological cycle, is essential for designing more effective mitigation actions against the impacts of these extremes. The runoff number (N) from the widely applied SCS (Soil Conservation Service) method for estimating peak flood discharges depends on land use and hydrologic soil type. Assigning hydrologic soil types to mapped soil units is hampered by the varying legends of Soil Maps across different regions of Portugal. This study aimed to produce a hydrological classification and mapping of soil hydrologic types using a composite Soil Map consisting of three original maps: Central Inland Zone (ZIC), Trás-os-Montes (TM), and Entre-Douro e Minho (EDM), covering Northern, Northeastern, and Central Inland Portugal. The legends of these sources were harmonized based on soil characteristics distinctive of SCS hydrologic soil groups (A, B, C, and D). Soil depth distinguishes the main taxonomic groups and is a criterion in land capability classification. Analytical data from soil profiles in the sources include drainage porosity, which is dependent on organic matter (distinguishing secondary taxonomic groups), and texture, associated with the soil parent material. Based on these elements, soil units from the three maps were classified. The hydrologic type assigned to each mapping unit corresponds to the dominant soil unit within it. The outcomes of this work are (i) a list of soil units and cartographic units classified by hydrologic soil type, and (ii) a map showing the distribution of hydrologic soil types across Northern, Northeastern, and Central Inland Portugal. In terms of runoff potential, from lowest to highest, the hydrologic soil types are represented as follows: A, 13%; B, 13%; C, 21%; and D, 53%, which includes rock outcrops and urban areas (5% and 2%, respectively). Anthrosols have an important weight in the representation of soils classified as hydrological type A (88%), nd epileptic Umbrisols and epileptic Regosols in type D (36% and 34%, respectively). The four most prevalent soil units in the map are Epileptic Umbrisols (17%), Epileptic Regosols (16%), Endoleptic Regosols (15%), and Anthrosols (12%). Due to the improvement in the quality of territorial-scale information on hydrologic soil types, the results of this study are expected to enhance the estimation of runoff extremes in the Portuguese territory.

KEYWORDS

Hydrological soil types; Runoff number; Soil mapping; Hydrological extremes.

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GT 05 - 1100 - P

PRELIMINARY ASSESSMENT OF SOIL ERODIBILITY IN INLAND CENTRAL AND NORTHERN PORTUGAL

GT 05. SOIL HYDROLOGY & EROSION / GT 05. SOIL HYDROLOGY & EROSION

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Soil conservation is a major global concern and is integrated into several United Nations Sustainable Development Goals (SDGs), especially Goal 15, which addresses combating desertification and halting and reversing land degradation. Due to land management practices and natural conditions, Portugal is particularly prone to water erosion and faces the challenge of mitigating this natural yet often accelerated phenomenon. Therefore, assessing the factors that drive soil erosion is essential to understand this process better and to develop effective strategies to halt or reverse land degradation.

This study presents an initial assessment of the soil erodibility factor in the inland central and northern regions of Portugal, covering an area of approximately 39.091 km2. The soil erodibility factor (k) from the Universal Soil Loss Equation (USLE) was calculated using data from 666 soil profiles described in the regional soil map.

Soil erodibility was analysed at two levels: the Soil Unit (SU), for which the K value is defined as the median of the specific soil profiles, and the Map Unit (MU), which may comprise up to three SUs, with the K factor calculated as a weighted average of their corresponding SUs.

The outcome of this first assessment is a reference dataset of K values at the profile, SU, and MU levels, along with a soil erodibility factor map. In the study area, the mean K factor for fine earth is 0.038 +- 0.015 ton ha-1 (MJ ha-1 mm h-1)-1, indicating a moderate susceptibility to erosion. The variability of K averages around 40%, reflecting significant soil erodibility heterogeneity across the territory. Preliminary results indicate that the Dystric Regosol is the most dominant SU, covering 19% of the area and presenting an average K of 0.040 ton ha-1 (MJ ha-1 mm h-1)-1.

Although preliminary, this study highlights both the moderate susceptibility to erosion and the marked spatial heterogeneity of soil erodibility. The resulting dataset provides a valuable basis for generating more reliable information to support robust erosion risk assessments and informed land management strategies. Further research should deepen the understanding of how soil erodibility is distributed across the region, with particular attention to factors such as soil stoniness (>2 mm) and the presence of rocky outcrops.

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GT 05 - 1105 - P

SOIL MOISTURE DEVELOPMENT IN SMALL FOREST CATCHMENTS AFFECTED BY BARK BEETLE OUTBREAK – RESULTS OF A THREE-YEAR STUDY IN THE JESENÍKY MTS., CZECH REPUBLIC

GT 05. SOIL HYDROLOGY & EROSION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The bark beetle outbreak, that peaked in 2018-2022 lead to loss of forest cover in Central Europe with more than 200 thousands hectares of clear-cuts in the Czech Republic. The impact of partial deforestation on the water balance of small forest catchments is being studied in the Jeseníky Mountains in the northwest of the country. Part of the study focuses on the development of soil moisture in clear-cuts compared to original Norway spruce stands. Three research sites were established in different altitude zones (660 m, 780 m and 1020 m a. s. l.) of the area, each including three individual plots in clearing, younger stand (30-60 years) and mature stand (90-130 years) of Norway spruce. All plots were equipped by precipitation gauges, soil (volumetric) moisture sensors, and soil water potential sensors in soil depths of 10 cm, 30 cm and 50 cm. Measurements were carried out since May 2022 till November 2024, the course of soil moisture during the vegetation period is evaluated.

Higher soil moisture and higher (less negative) soil potential were generally observed in the clear-cuts compared to forest stands. Differences between younger and mature forest stands were not uniform and were influenced by the stand density and soil texture. Surprisingly, differences in soil moisture between different research sites were not significant, although the amount of precipitation increases with altitude. The region is obviously water-saturated for most of the year and local conditions are influenced not only by precipitation, interception and soil condition but also by vertical and lateral water flow in the soil profile. There were identified few drought periods ($\Psi \leq -1{,}5$ Mpa) in the upper soil layer (10 cm) in July 2023 and August/September 2024 in forest stands, which can be connected with the stand transpiration.

The results show, that in case of Jeseníky Mts. the effect of clear-cutting on soil water does not affect water balance of catchments in a substatnial way. Higher soil moisture in clear-cuts is temporary and deceasing with expanding grass cover and reforestation. We also tried to calculate the effect of “reduced” water retention capacity of clear-cuts (comparing to forests) in case of extreme rainfall and following floods in September 2024, which, however, appears to be negligible.

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GT 06. SOIL PRODUCTIVE SECTORS ECONOMY AND SUSTAINABILITY

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 06 - 19 - P

AGRICULTURAL SOILS AND CLIMATE ACTION: IMPROVING SOC SEQUESTRATION THROUGH ADVANCED MRV FRAMEWORKS

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Agriculture is a significant driver of climate change, contributin g at least 22% of global greenhouse gas (GHG) emissions (IPCC, 2023). Agricultural soils are vital for food security, sustainable development, and serve as the largest terrestrial carbon reservoir, enhanced by better land management. As observed by McDonald et al. (2021) carbon-smart agricultural practices, such as conservation tillage, organic farming, cover cropping, and crop rotation can significantly influence the balance of soil organic carbon (SOC), potentially causing rapid mineralization that releases carbon as CO2 into the atmosphere. Conversely, carbon retained in the soil can contribute to reducing atmospheric CO2 levels. SOC sequestration can be integrated into carbon offset mechanisms, providing financial incentives for farmers while supporting global climate goals. SOC-focused carbon offsets allow land managers to receive compensation for carbon removal and storage, while other sectors gain the means to offset their emissions. Despite this potential, current carbon measurement/Monitoring, Reporting, and Verification (MRV) methodologies present significant challenges, including complexity, high costs, and insufficient accessibility for farmers (Paul et al., 2023). Therefore, the aim of this study was to conduct a systematic literature review and analyze regulatory protocols, standards, and MRV initiatives to pinpoint key gaps in existing frameworks and design a conceptual methodology specifically suited for agricultural SOC sequestration.

Findings demonstrate that improved MRV processes can facilitate the quantification, monitoring, and reporting of SOC changes while addressing barriers to adoption. According to McDonald et al. (2021), reporting entails a structured process for communicating findings, while verification is essential to ensure accuracy, completeness, and credibility. Accurate accounting of SOC changes in agriculture should rely on established measurement and monitoring methods, such as field-based direct measurements, modeling techniques, remote sensing, or lookup tables. The selected approach should be straightforward to implement, considering local climate and soil conditions, to reduce costs for both administrators and farmers (Meena et al., 2024). After SOC changes data collection, all relevant information must be systematically compiled and reported. For SOC change reporting, carbon project developers should identify the earliest reliable baseline data. Reporting intervals typically range from 1 to 5 years for soil carbon projects. Additionally, developers must select a permanence period of either 25 or 100 years, during which the sequestered carbon must remain intact. Registering a soil enrichment carbon project requires submitting multiple reports, including a pre-implementation report, an initial report, bi-annual progress reports, and a final report. To ensure compliance with established requirements, an external auditor must review the measurement and monitoring outcomes to verify the amount of greenhouse gas mitigation achieved and documented. Following successful verification, carbon credits may be issued. These credits can be allocated using various payment models, such as action-based, results-based, or hybrid approaches, offering flexibility and incentives for farmers participating in carbon offset initiatives (Raina et al., 2024).

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GT 06 - 231 - P

OPTIMIZING WATER-SAVING IRRIGATION STRATEGIES: INTEGRATIVE ASSESSMENT OF SOIL QUALITY, CROP YIELD, GREENHOUSE GAS EMISSIONS, AND MICROBIAL DIVERSITY IN RICE PADDIES

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 09. SOIL HEALTH

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Water availability is crucial for global food security, and water-saving irrigation is key to addressing water scarcity and reducing greenhouse gas (GHG) emissions. However, few studies have evaluated multiple irrigation intensities within a single field experiment, limiting direct comparisons of their agronomic and environmental impacts. This study assessed the effects of traditional continuous flooding (CF) and two other water-saving irrigation methods on rice yield and GHG emissions. An integrated Soil Quality Index (SQI) incorporating GHG mitigation potential, soil fertility indicators, and microbial diversity, were developed to evaluate soil function under different irrigation regimes. A key innovation of this study lies in its holistic assessment of water-saving irrigation impacts on soil quality, crop productivity, GHG emissions, and microbial biodiversity within a single, field-scale experimental setting—offering an integrated perspective that has been lacking in prior research. The results indicated that the Alternate Wetting and Drying (AWD) method, implemented according to International Rice Research Institute (IRRI) guidelines, reduced water use by approximately 23% without compromising rice yield. Periodic irrigation (PI)—implemented as irrigation every nine days—achieved a greater water saving of 60% but led to a significant yield decline of approximately 19%. Methane emissions decreased with reduced irrigation, but this was counterbalanced by elevated N_2O emissions, resulting in no net reduction in global warming potential. Overall, neither of the water-saving irrigation methods significantly affected the SQI, indicating their sustainability potential—particularly AWD, which synergistically conserved water, maintained yields, and enhanced microbial diversity.

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GT 06 - 316 - P

VALIDATION OF LAND-CAPABILITY CLASSIFICATION OF CROPLAND IN THE BASQUE COUNTRY USING PRECISION AGRICULTURE YIELD MONITORS

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Attempts have been made to identify the soils with the highest capacity to produce food. The USDA developed a land-capability methodology [1] that classified soils into 8 categories; soils suited for cultivation were classified in Class I, II, III, or IV, with Class I being the most suitable for food production. This methodology was adapted by the MAPA-Spanish Ministry of Agriculture [2].

Nowadays, precision agriculture makes it possible to identify different soils and areas within a plot to tailor inputs (irrigation, fertilisers, etc) to their capabilities, but not all farmers can afford this technology. In this work, (i) the land-capability classification of the cropland area of Vitoria-Gasteiz (Basque Country) was carried out by adapting the MAPA methodology and (ii) it was compared with the productivity data obtained using yield monitors, to validate this adapted methodology that could be applied to a larger area in a simple way.

With the support of 254 field observations (43 of them were profiles), the MAPA methodology was adapted to the conditions of Vitoria-Gasteiz and 10,800 ha of cropland were classified. This adaptation involved slope, land use, 10-year return period floodability and Topographic Position Index. Productivity was measured using yield monitors installed on GPS-equipped farmers' tractors. 3,369,074 values were recorded in 4,762 hectares harvested for 6 years (2019-2024). Differences between the averages were tested by ANOVA with Tukey's HSD test.

Wheat was the most harvested crop according to yield monitor data (2,594 ha harvested in 2019-2024). The statistically highest yield was observed on soils classified as Class I, followed by those classified as Class II, Class III, and Class IV in all years, in that order (e.g, 7.3, 6.5, 5.8, and 5.5 Mg ha-1, in 2020). This trend was also seen in other crops with less monitored area (barley, oats, rapeseed), although not as clearly in all years.

Land-capability classification adaptation used in Vitoria-Gasteiz was successfully validated through yield-monitoring technology, encouraging its application to larger cropland areas under similar conditions. These relatively easy-to-obtain land-capacity maps can be used by farmers to implement more efficient agricultural practices, and by policymakers to develop territorial regulations that ensure balanced soil utilization. This is relevant in the Basque Country, where population density is high and there is increasing competition for soil use (food, construction, energy, etc).

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GT 06 - 334 - P

THE ROLE OF SOIL VARIABILITY IN MODULATING VINE VIGOR AND GRAPE QUALITY IN THE CALCAREOUS HILLS OF PIEDMONT, NORTHERN ITALY

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 09. SOIL HEALTH

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Wine is among the most valuable agricultural products worldwide, with a strong connection with its territory. However, grapevine cultivation practices in conventional systems are often poorly sustainable, leading to a decrease in both plant productivity and soil health. Italy ranks fourth globally in vineyard area, with approximately 720,000 ha cultivated in 2024. More than 40.000 ha are in the Piedmont region, with about 20% located in the Langhe and Monferrato hills. The soils in this area are calcareous, clay-rich and low in organic matter (OM), vulnerable to continuous erosion driven by slope and land use. Two of the main grapevine varieties cultivated here are Barbera, appreciated for its versatility, and Nebbiolo, a prestigious, region-specific variety known for its higher resource demand. Both are included in the Piemonte Living Lab of the LivingSoiLL project. Assuming that these two varieties would exhibit different responses due to their different degree of plasticity, our goal was to investigate how spatial variability in soil properties correlates with variability in grapevine vigor and berry characteristics.

In 2024, we selected two study areas characterized by similar climatic conditions, with a mean annual temperature of 13 °C and average annual precipitation of 700 mm. Both areas featured comparable soil development (Entisols). Grid-based sampling designs were implemented, and topsoils (0-30 cm depth) were collected at the base of selected grapevines, which were assessed for vigor (NDVI and pruning mass) and grape quality (percentage of damaged fruit and basic fruit chemistry). At both sites, topography influenced the distribution of particle size classes along the slopes. Available phosphorus (P) was higher in areas with higher OM or clay contents, while bulk density was correspondingly higher in OM-poorer areas.

For both cultivars, grapevine vigor was greater: (i) where the percentage of damaged fruit was higher, likely as a result of an excessive canopy growth that favored fruit rot during the unusually rainy 2024 season and (ii) where the degree of fruit maturation was lower. In Nebbiolo, plant vigor showed a strong correlation with soil moisture, whereas in Barbera the relationship was weaker, with vigor hotspots more strongly associated with OM content. This may reflect Nebbiolo's greater sensitivity to drought stress compared to the more drought-tolerant Barbera, whose vigor increased in areas with higher OM levels, likely due to the indirect effects of OM on nutrient availability. These findings underscore the significant impact that even subtle soil properties variations can have on grapevine performance, especially in heterogeneous landscapes like the Langhe and Monferrato hills. Understanding cultivar-specific responses to soil variability is therefore essential for developing more site-specific vineyard management strategies, particularly in the context of increasing climatic variability.



GT 06 - 335 - P

REGENERA.CAT PROJECT: FARMING THE LAND WITH REAL FARMERS IN ORDER TO COMBAT CLIMATE CHANGE AND RESIST DROUGHT

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 09. SOIL HEALTH

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With increasing drought and anthropogenic climate change, agriculture in Mediterranean regions like Catalonia must evolve to ensure food security. Against this context, regenerative agriculture offers an attractive solution to enhance the resilience of farming systems and reduce environmental pressure. Understanding how it works under on-farm conditions is essential to scale up sustainable solutions.

“Regenera-cat” is a two-year project supported by the Agency for Management of University and Research Grants (AGAUR) of the Catalonia Government. It aims to assess the impacts of practices implemented in regenerative and enable the understanding of applying these practices in this global change environment, as well as solutions to adapt to future climate condition and integrate it into the solution of present environmental issues.

The initiative joins the scientific expertise of CREAF and ICTA-UAB with the actual field experience of five Catalan farmer-managed farms—Planeses, Verdcamp Fruits, Família Torres, Pomona Fruits, and Arion—that have implemented regenerative agriculture for several years. Every farm is a representation of one of the five most typical Mediterranean cropping systems: pastures, horticulture, vineyards, orchards, and olive groves, respectively. To evaluate the scientific benefits, traditional and regenerative farming practices were compared using crop-associated biodiversity (e.g., bees for pollination), soil health and fertility, carbon sequestration capacity, water retention capacity, crop productivity and quality, carbon and water footprint, and economic and social aspects.

In soils, physico-chemical properties such as organic carbon, total nitrogen, pH, carbonates, phosphates, electrical conductivity, and ion concentration were quantified to analyze the effect of different regenerative management in different situations on soil health and fertility. Preliminary results indicate improvements in some properties under some regenerative managements, particularly organic carbon content. Topsoil temperature and moisture were also measured using sensors, early results indicating greater resistance to drought and warming in regenerative plots.

In conclusion, the Regenera.cat project has demonstrated the positive impacts of regenerative practices on some real, working farms, providing valuable insights into how these practices enhance soil health and fertility, biodiversity, and crop performance.

GT 06 - 626 - P

COMPARATIVE STUDY OF SOIL PROPERTIES IN SHRUB AND GRASSLAND AREAS

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 16. CONNECTING PEOPLE AND SOILS

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Soil is a non-renewable natural resource that plays an essential role in the provision of fundamental ecosystem services, such as biomass production, water regulation, biodiversity conservation and erosion control. In the framework of the Reactiva Brañosera project (BP 220) a specific action has been designed to evaluate soil quality and its capacity to sustain these ecosystem services. This evaluation considered the potencial impact of silvicultural practices in grasslands and shrublands on the physical, chemical and biological soil properties. The proposed methodology includes a comparative approach between two land uses: shrubland and grasslands. Within each land-use category, various treatments were applied to analyze their effects on soil properties. The selected soil quality indicators included texture, structure, bulk density, porosity, organic matter content, available phosphorus, pH, cation exchange capacity and base saturation. One of the most relevant results derived from this analysis is the estimation of soil organic carbon stock. The comparative evaluation will allow us to assess the impact of actions in soil properties. These results are essential for characterizing the ecological status of the region, guiding decision-making processes for land managements improvements, and evaluating the effectiveness of interventions implemented.

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GT 06 - 684 - P

ECOSPHEREWINES - IMPROVEMENT OF ECOSYSTEM SERVICES AND GREEN INFRASTRUCTURE IN ECOLOGICALLY VALUABLE VITICULTURAL AREAS

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 09. SOIL HEALTH

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The ECOSPHEREWINES project focuses on improving landscapes linked to vine cultivation—an essential economic and tourism resource in the SUDOE area, especially in inland territories affected by depopulation and aging. In these regions, preserving natural and environmental capital is crucial for rural communities, as it serves as a source of wealth.

The objective of this project is to enhance the ecosystem services provided by vineyard agricultural landscapes through the implementation of a green infrastructure network in areas of high ecological value. This strategy is aimed at conservation and sustainable management, improving biodiversity, and increasing resilience to climate change. To achieve this, the project will:

- Analyze current green infrastructure practices,
- Identify barriers and opportunities,
- Test a tailored methodology in pilot areas of Spain, France, and Portugal.

Theongoing activities and final results will guide future planning and be scaled across the Iberian Peninsula and southern France, supporting rural development through enhanced biodiversity, tourism, and environmental health.

Pilot areas where green infrastructure is being implemented include:

- Spain: Galicia and Castilla y León (biosphere reserves),
- France: Gaillac region (Occitania),
- Portugal: Douro region (Foz Côa, Natura 2000 site).

In the case of Galicia, the experimental field site is located in Betanzos, A Coruña (43°17’04.5”N, 8°11’17.7”W), within a vineyard owned by the winery Pagos de Brigante S.L. The Betanzos wine-growing region reached its peak cultivation in the late 18th century, covering approximately 1,100 hectares. However, it experienced a significant decline in the 19th century due to a series of devastating vine diseases, including powdery mildew, downy mildew, and phylloxera. By the mid-20th century, the vineyard area had been reduced to just 117 hectares. As a result of this abandonment, much of the land was reforested with eucalyptus for timber production.

Today, several small wineries—including Pagos de Brigante S.L.—are actively working to revive traditional viticulture in the region. Within the framework of the ECOSPHEREWINES project, multiple nature-based solutions are being implemented and tested. These include the introduction of cover crops, application of mulching, establishment of melliferous flower strips, restoration and maintenance of dry-stone walls, restoration of wetlands and riparian forests, erosion control measures on slopes, and crop diversification within the vineyard. The primary field actions and corresponding results will be presented.

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GT 06 - 887 - P

MAPPING FUNDING MECHANISMS FOR THE ACTORS IN THE DELISOIL SUPPLY CHAINS TO TRANSFORM FOOD SIDE STREAMS OR SIDE STREAMS INTO “SOIL IMPROVERS” (INCLUDING FERTILISERS AND BIOSTIMULANTS): A CROSS-COUNTRY ANALYSIS OF PUBLIC AND PRIVATE FUNDING SCHEMES IN 5 LIVING LABS.

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Background and objectives:

Developing market-relevant soil improvers from food production side streams within a circular economy framework requires more than technological readiness and regulatory innovation. It also demands access to tailored financial instruments. This is particularly true for soil improvers that do not offer immediate or evident benefits to farmers, as the pivotal end users. Within the Horizon Europe project DeliSoil, we map and evaluate public and private funding schemes across five European countries, where DeliSoil Living Labs are active, as well as selected schemes from other relevant regions. The goal is to identify effective instruments, highlight systemic gaps, and support the replication of the most promising business cases across contexts and value chains.

Methods:

A structured classification approach was developed to assess three categories of funding schemes: (1) Public (CAP eco-schemes, grants, public loans), (2) Private (including coinvestments, premiums, commercial loans, and VC/PE), and (3) Carbon credit markets.

Each scheme was analysed based on stakeholder targeting (e.g. food producers, processors, technology providers, fertiliser manufacturers, farmers), eligible practices, financial scope, recurrence (one-time vs. annual), and regional applicability. The analysis also considered coherence with DeliSoil technologies developed in living labs (composting, anaerobic digestion, HTC, pelletisation), and it was built upon partner inputs ,official documents, AI-supported searches, and iterative expert validation.

Results and discussion:

Funding landscapes vary widely. Public instruments are generally farmer-oriented, often promoting compost application or nutrient recycling; however, their support for upstream valorisation steps is less evident. In contrast, private co-investment mechanisms, although less widespread and less publicly known, offer targeted capital for innovation and market

deployment, primarily where clear business opportunities can be envisioned. Biostimulants emerge as a high-potential case that may require a dedicated analysis beyond this broader analysis. Preliminary results highlight best-practice examples such as private co-investments by Yara–Nordzucker and Yara–PepsiCo, as well as public programmes like FAKT II (Germany). Public–private hybrids are also expected to play a

significant role in the near future.

Conclusion:

By making funding schemes visible and comparable, DeliSoil supports stakeholders in identifying financial enablers and developing viable, regionally adapted business models for circular soil improvers, thereby contributing to the EU Soil Mission.

ACKNOWLEDGEMENTS

The authors acknowledge the contributions of the DeliSoil Living Lab coordinators and project partners for providing valuable data and insights. Special thanks to Marina Ettl (Former member of Yara International) for input regarding co-investment mechanisms. This work has received funding from the European Union’s Horizon Europe Programme under Grant Agreement No. 101112855.



GT 06 - 924 - P

OPTIMIZATION OF AGRONOMIC PARAMETERS FOR SPRING CAMELINA SATIVA PRODUCTION IN QUEBEC

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Camelina (Camelina sativa L. Crantz) is a traditionally cultivated oilseed crop with over 4,000 years of use, primarily for its oil content [1]. With the intensification of agriculture, it was progressively replaced by higher-yielding crops such as canola. In recent years, camelina has been receiving renewed attention in Europe and North America due to its agronomic resilience, nutritional properties, and potential for biofuel production [1,2]. In Quebec, camelina remains a less common crop, despite increasing interest from both farmers and researchers aiming to diversify cropping systems. Its broader adoption is currently limited by a lack of agronomic knowledge adapted to local climatic conditions. Sowing date and varietal choice are key factors likely to affect seed yield.

To address this, field trials were conducted in 2024 at three locations :Montérégie, Capitale-Nationale, and Témiscamingue, representing distinct pedoclimatic zones. The objective was to identify optimal conditions for spring camelina production by evaluating different sowing dates and varieties. The study also examined their effects on crop development and plant density, both of which are closely linked to seed yield. Preliminary results show no significant differences in seed yield among the tested varieties ($p > 0.05$). However, both sowing date and location had significant effects ($p < 0.05$). In addition, the duration of the crop cycle appeared to be influenced by site-specific climatic conditions, particularly temperature, which may impact establishment, growth, and final seed yield. These findings suggest that sowing dates should be adjusted according to regional pedoclimatic conditions to optimize camelina production in Quebec.

ACKNOWLEDGEMENTS

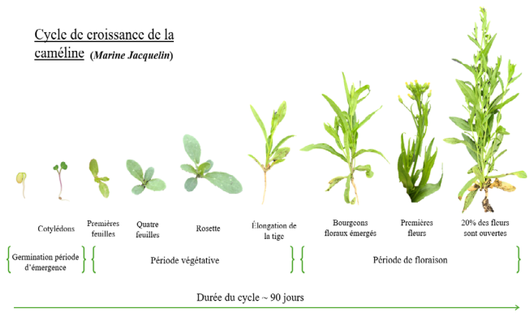
I would like to warmly thank my research supervisor for the trust placed in me in managing this project, as well as the entire research team for their support and collaboration. Special thanks go to Bérenger Bourgeois for his valuable assistance with statistical analyses, and to Stéphanie Lavergne for her active collaboration throughout the project. I also extend my gratitude to our partner producers and the organizations that supported this research, including CRIV, Université Laval, and MAPAQ.

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Cycle de croissance de la caméline

GT 06 - 962 - P

DIS-COVER-CROP PROJECT - DIVERSIFICATION WITH COVER CROPS - SUSTAINABILITY IN POTATO PRODUCTION

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 16. CONNECTING PEOPLE AND SOILS

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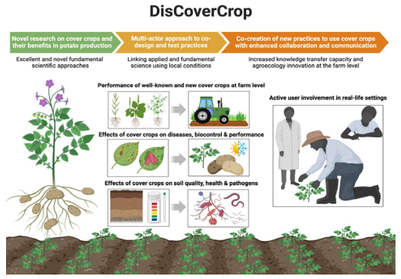
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The European Union (EU) is committed to transforming its agri-food systems to be more environmentally sustainable and resilient. A key strategy for achieving these goals is the use of crop diversification, specifically the incorporation of winter cover crops into potato rotations. However, the benefits of cover crops for potato cultivation are not fully recognized or exploited in some countries, particularly in the major production areas of northwest Europe. Our DisCoverCrop (Diversification with cover crops - sustainability in potato production) project aims to address this gap by determining effective cover crop strategies for potato production in Estonia (EE), Sweden (SE), Norway (NO), Netherlands (NL) and Germany (DE) and providing evidence-based communication for their use. To achieve this, field experiments are planned across different locations and climate conditions in research farms and through farmer-led field trials. These experiments will evaluate both established cover crops and novel plants suitable as cover crops, assessing their impact on soil functions, disease incidence, the integration of microbial biocontrol agents, plant performance, soil microbial community diversity, and potato yield. Currently, workshops surveying both researchers and practitioners are being prepared to identify knowledge gaps, beliefs, and communication needs among the participants. The project will use this information in a co-creation, multi-actor approach, involving all relevant stakeholders in the design, implementation, and evaluation of the experiments. We will also strive to ensure socio-economic factors are considered for end users. Our transnational approach brings together stakeholders and researchers from EE and SE (where a few early adopters use cover crops) and NO (where cover crops are not yet used) with more experienced cover crop users in NL and DE. Our focus stakeholders in SE are starch potato producers, whilst in NO we will work closely with table potato producers. To showcase the benefits of cover crops and encourage their adoption, demonstration plots that will serve as lighthouses, and field days will be organized. Based on the project findings, recommendations will be developed for the practical use of cover crops in potato rotations, highlighting their adaptability to different potato production systems in northwestern Europe. Our findings will provide valuable data for both national and EU level agri-food policies, and the increased awareness and adoption of cover crops will benefit the agricultural community, consumers, and the environment. The EUROSOIL 2025 offers an outstanding opportunity to disseminate and discuss our ideas within the European soil science community at the very beginning of our project, thereby amplifying the impact of our research approach and findings.

ACKNOWLEDGEMENTS

Thanks to the respective national funders



Conceptual diagram of DisCoverCrop project (Diversi?cation with cover crops - sustainability in potato production).



GT 06 - 1050 - P

COVER CROPS AND THEIR INFLUENCE ON SOIL SEED BANK GERMINATION

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 04. SOIL BIOLOGY

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Cover crops are increasingly being recognized as a sustainable tool in agroecological systems, providing both environmental and agronomic benefits. Among their key functions, the suppression of weed seed germination through competition and allelopathy has become a focus of interest, particularly in systems aiming to reduce herbicide inputs.

This study aimed to evaluate the influence of biodiverse cover crops on the germination of weeds, from soil seed banks, in 5 different fields. Each field included two distinct management areas: one using conventional practices (Control) and another implementing annual biodiverse cover crops (CC).

Soil was sampled systematically and used to fill germination trays, with three replicates per sample. Seedling emergence was monitored over a six-week period, with observations made every 15 days. Emerging seedlings were morphologically identified, categorized as monocotyledons or dicotyledons, photographed, and subsequently removed after recording.

Statistical analysis was conducted using Student's t-tests, descriptive statistics, and quantile-quantile plots to assess the differences in seedling emergence between treatments.

Results showed a stronger inhibitory effect of cover crops on monocotyledonous seedlings, particularly grasses (Poaceae), than on dicotyledons. The ratio of seedling emergence between Control and Cover Crop treatments was 1.8 for monocotyledons and 1.6 for dicotyledons, with statistical significance ($p = 0.01$).

The data suggest that cover crops, especially those combining Poaceae, Brassicaceae and Fabaceae species, can significantly reduce seed germination in weed seed banks.

The implications of this research include a potential reduction in the need for residual herbicides, contributing to lower environmental impact, particularly in aquatic ecosystems, and improved soil biodiversity. This aligns with the goals of promoting more resilient and sustainable farming systems.

Future studies will focus on identifying specific weed species affected and further exploring the suppressive potential of cover crops against problematic and herbicide-resistant species such as Cyperus spp., Datura stramonium, and Solanum nigrum.

GT 06 - 1057 - P

AGROFORESTRY FOR THE FUTURE: STRATEGIC PATHWAYS FOR CLIMATE ADAPTATION AND TERRITORIAL INCLUSION IN BRAZIL

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The resilience of agri-food systems has become a central issue in the face of growing challenges posed by climate change, environmental degradation, and food insecurity. In this context, Agroforestry Systems (AFS) emerge as a promising strategy, fostering the socioeconomic and environmental sustainability of rural properties. In addition to enhancing productive diversification, AFS contribute to the conservation of natural resources, the mitigation of greenhouse gas (GHG) emissions, and the increased resilience of rural communities.

In Brazil, approximately 18.5% of the national territory (around 159 million hectares) is occupied by pastures, 78% of which show some degree of degradation. This situation compromises soil quality, reduces water infiltration, and lowers agricultural productivity, leading to significant socioeconomic and environmental impacts. In response, the Brazilian government launched the National Program for the Conversion of Degraded Pastures (PNCPD), through Decree No. 11.815/2023, aiming to promote sustainable agricultural and forestry systems capable of restoring soil health, increasing carbon sequestration, and supporting climate adaptation.

Minas Gerais has distinguished itself by its environmental commitment, becoming the first state in Latin America to join the Race to Zero campaign, which seeks to achieve net-zero emissions by 2050. Within this framework, the present study aimed to identify priority areas for the implementation of AFS in the state, using geospatial and socio-environmental data.

The methodology was based on the analysis of the MAPSAF (Mapping of Agroforestry Systems) platform, with specific data extracted for Minas Gerais. Properties with AFS were cross-referenced with data from the Rural Environmental Registry (CAR), considering variables such as geographic location, land area, soil types, lithology, topography, and socioeconomic context.

A total of 103 properties with AFS were identified in the state. The majority are located in the Zona da Mata region (29 properties), and in the South and Southeast regions (16 properties), characterized by rugged terrain, a tropical highland climate, and a strong tradition of coffee cultivation and environmentally certified pastures. In contrast, the Mucuri and Jequitinhonha Valley regions had the lowest number of properties with AFS, despite their rich biocultural diversity. These regions face persistent challenges such as water scarcity, poorly developed soils, and low Human Development Index (HDI) scores.

The study underscores the uneven distribution of AFS across Minas Gerais, with higher concentrations in economically and logistically advantageous areas. In contrast, vulnerable regions such as the Jequitinhonha and Mucuri Valleys lack targeted public policies that encourage agroforestry practices as tools for poverty reduction, environmental restoration, and climate change adaptation. The findings provide valuable technical and spatial inputs to support development programs and sustainable land-use policies in the state.

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GT 06 - 1058 - P

SOIL MANAGEMENT EFFECTS ON CROP PRODUCTION AND SOIL HEALTH: INSIGHTS FROM FOUR SWISS LONG-TERM FIELD TRIALS

GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY / GT 09. SOIL HEALTH

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Sustainable soil management is key to maintaining productive agricultural systems and healthy soils over the long term. This study synthesizes data from four Swiss long-term field experiments (LTEs) to evaluate how different soil management practices impact crop yields, nitorgen (N) fertilizer use efficiency and key soil health indicators. Included are the concluded trials Chaiblen (1989–2000, Jossi et al., 2002) and Burgrain (1991–2008, Zihlmann et al., 2010), and the ongoing trials FAST (2009–present, Wittwer et al., 2021) and Oberacker (1995–present, Martínez et al., 2016a & b), which represent a range of conventional, integrated, conservation agricultural and organic management systems.

Archived and recent data were restructured and harmonized using the R-package SoilManageR (Heller et al., 2025), enabling a consistent quantification of management indicators (e.g. tillage intensity, carbon input, soil cover, N fertilization intensity, plant protection intensity) and their relation to outcomes such as yield, soil organic carbon, biological activity (e.g. earthworm biomass), and water retention capacity. Weather data was integrated to contextualize yield variability and soil responses.

Initial analyses indicate that systems with higher C inputs, and greater soil cover support higher levels of soil organic matter, better biological activity. This work highlights the long-term benefits of sustainable soil management for agricultural performance and ecosystem functioning. By re-evaluating legacy datasets alongside ongoing trials, the study contributes to evidence-based strategies for improving soil health and crop production under evolving environmental and economic pressures.

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GT 07. SOIL AMENDMENTS & FERTILIZERS

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 07 - 29 - O

LONG-TERM (71 YEARS) NITROGEN AND LIME APPLICATION IMPACTS MICROBIAL RESILIENCE, STOICHIOMETRIC CONSTRAINTS, AND SOIL CARBON STABILITY IN A SEMI-ARID GRASSLAND.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Grasslands, inherently nitrogen-limited, face intensifying pressure from fertilization practices aimed at improving productivity. This study investigated 70 years of nitrogen (N) fertilization (ammonium sulphate (AS) vs. ammonium nitrate (AN) at 70 and 211 kg N/ha and lime application in a South African semi-arid grassland. The approach integrated plant biomass, stoichiometry, and microbial activity to examine soil organic carbon (SOC) stability drivers. Above-ground biomass increased by 202 – 218% under high N rates (AS211, AN211), while lime alone had no effect. Ammonium sulphate significantly acidified soils (pH 3.27 – 4.11), yet unexpectedly elevated dehydrogenase activity (389 – 402µg TPF/g vs. control: 95.9 µg TPF/g), suggesting microbial adaptation to acidic conditions. Lime restored soil pH (e.g., AS211L: 6.63) but did not enhance SOC despite mitigating acidity. Below-ground responses revealed stoichiometric constraints: root C:N ratios declined in limed plots (e.g., AN211L: 27), while high shoot C: N ratios (41) indicated recalcitrant litter inputs. Critically, SOC remained due to pH-driven shifts in microbial efficiency (high dehydrogenase activity but low MBC in AS plots) and stoichiometric mismatches (C:N > 40 in shoots), limiting decomposition. Root N:P ratios (>14 under high N) signaled phosphorus limitation, further complicating nutrient cycling. These findings show that carbon sequestration in fertilized grasslands may not be constrained by productivity but by microbial carbon use efficiency and litter quality. Lime co-application is recommended with acidifying N sources to balance pH and propose root stoichiometry as a critical indicator of soil health. The findings revealed the role of microbial resilience in acidic soils and offer insights for sustainable grassland management under global change.

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GT 07 - 78 - O

AGRONOMIC ASSESSMENT OF BIOCHAR VALORIZATION IN AN ACIDIC AND LOW PHOPHORUS SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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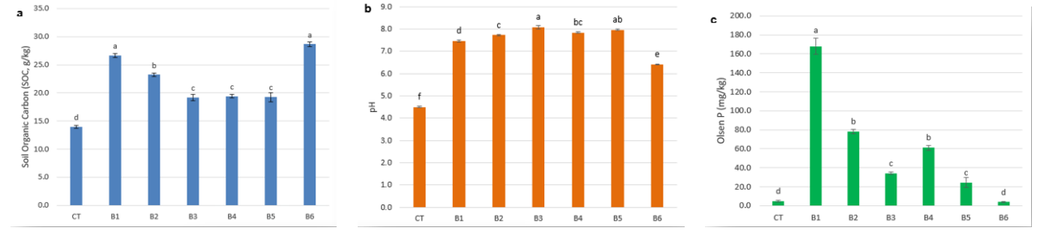
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Biochar is made by heating organic matter with a limited supply of oxygen through a process called pyrolysis and it can be used as a soil amendment. However, the characteristics of the lignocellulosic source materials and the pyrolysis temperature seem to change the agronomic behavior of the biochar. The aim of this work was to assess the effect of six biochars produced from different organic sources and under various pyrolysis temperatures on soil fertility, namely on soil organic C (SOC), pH, phosphorus availability (soil Olsen-P), and on crop biomass. It was carried out through a micropot experiment, over thirty-four days, in a growth chamber using triticale (× Triticosecale Wittmack, var. Misionero) sown in low P and acidic soil. Each pot was filled with 150 g of soil mixed with 8.25 g of biochar. The experimental design was completely randomized with seven treatments, each one with three replicates. Five biochars (B1 to B5) were derived from the pyrolysis at different temperatures of various proportions of poultry manure (PM) and date palm fronds (DPF). B1 was derived from a mixture of 50% PM and 50% DPF. For B2, the proportion was 45%, and 10% of calcined marble was added, while for B3, B4 and B5 the proportion was 37.5% with 25% of calcined marble. The pyrolysis temperature was set to 500 °C for B1, B2 andB3, 400 °C for B4, and 700 °C for B5. B6 was produced from wood material at 700 °C. A control treatment (CT) without biochar application was also carried out. All treatments were fertilized with a Hoagland solution made without P. The results showed that, regardless of the source, all biochars significantly increased SOC (Fig 1a) and the soil pH (Fig1b) compared with CT. Regarding the soil Olsen-P, the biochars B1-B5 also increased their soil levels (Fig 1c) compared to CT. Moreover, the biochars significantly increased the plant biomass compared to CT. However, there were significant differences in the agronomic behavior between the six biochars. B1 and B6 showed the highest SOC content, B3 and B5 the highest increase in soil pH, B1 the highest increase in soil Olsen-P and B2 and B4 the highest plant biomass production. These results highlight not only the positive agronomic behavior of biochar, but also the need for more comprehensive studies on the agronomic impacts of biochar sources and manufacturing conditions.

ACKNOWLEDGEMENTS

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a) Soil organic carbon (SOC); b) pH and c) soil Olsen P



GT 07 - 86 - O

ENHANCING PLANT RESILIENCE TO DROUGHT: THE POTENTIAL OF CARBON FROM METHANE PLASMALYSIS (CMP)-BASED SOIL AMENDMENTS ASSESSED THROUGH PHENOTYPING

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Drought stress, an increasingly common abiotic stress factor, significantly impacts plant physiological performance and biomass production. Carbon from methane plasmalysis (CMP) has demonstrated potential as a soil amendment, improving soil properties and promoting plant growth. However, the role of CMP, pelletized with different binding agents including water, kieselguhr, or chicken manure, in mitigating drought stress remains unexplored. This study examines the potential of these CMP-based pellets to strengthen plant resilience under drought conditions.

A greenhouse experiment was conducted in a high-throughput phenotyping growth chamber to evaluate physiological responses of summer wheat (Triticum aestivum L.) to drought stress. CMP-based pellets with different binding agents were applied to agricultural soil under both no drought stress and drought stress conditions. Daily in-situ measurements were performed to monitor plant growth dynamics, leaf surface area, and physiological adaptations. In addition, plant and soil analyses were conducted upon harvest. Carbon isotope ratio (13C/12C) analysis of aboveground wheat tissues was used to assess drought stress levels.

The application of CMP-based pellets alleviated the negative effects of drought stress by reducing the decline in leaf surface area, which was up to three times greater in control plants compared to those treated with CMP-based pellets. Furthermore, CMP application reduced leaf surface temperatures, potentially lowering plant water consumption by minimizing evaporative losses. Carbon isotope ratio analysis confirmed that wheat plants exposed to drought stress exhibited a less pronounced stress response when grown on soil treated with CMP-based pellets, indicating improved physiological adaptation. Data on soil water potential could interestingly not explain the improved plant growth under drought stress, therefore we assume a different mechanism involved in enhanced water-availability after CMP application.

These findings highlight the potential of CMP-based pellets as an effective soil amendment for enhancing plant resilience to drought stress. By improving water-availability for plants and moderating physiological stress responses, CMP-based amendments could contribute to more sustainable agricultural practices in drought-prone regions.

GT 07 - 104 - O

MACADAMIA HUSK COMPOST HAS THE POTENTIAL TO IMPROVE SOIL QUALITY IN A MACADAMIA ORCHARD

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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The use of Macadamia husk compost in orchards is becoming increasingly popular among macadamia farmers [1], including in South Africa. The application of macadamia husk compost to macadamia trees has the potential to improve the soil quality and, hence, increase the yield and quality of nuts. A two-year study investigated the effect of macadamia husk compost application rates on selected soil quality parameters in a macadamia orchard. Macadamia husk compost was mixed with pine bark and wood chips at the ratio of 30:35:35, respectively, and applied in August 2021 and 2022 after each harvest at the rate of 0 (control) t ha-1, 4 t ha-1, 8 t ha-1, and 12 t ha-1. The treatments were arranged in a Completely Randomized Block Design (CRBD) with four replications. Data on selected soil quality parameters were collected and subjected to statistical analysis using GenStat® version 17 (VSN International, UK).

The soil pH values of the compost-treated soils were significantly ($p<0.05$) higher than those of the control and increased with increasing compost application rate. Exchangeable potassium (K) increased with increasing compost application rate, with 12 t ha-1 having significantly ($p<0.05$) higher exchangeable K (268.75 mg kg-1) than 4 t ha-1 (190.63 mg kg-1) and the control (127.25 mg kg-1). Exchangeable Calcium (Ca) and available P at 8 t ha-1 compost application was similar to 12 t ha-1 but significantly ($p<0.05$) higher than the control and 4 t ha-1 compost application rate. Application of compost significantly ($p<0.05$) increased the levels of microbial carbon (MB-C), microbial nitrogen (MB-N), soil organic carbon (SOC), and particulate organic matter (POM) contents. Applying 12 t ha-1 of macadamia husk compost to the soil increased SOC, POM, MB-C, and MB-N contents by 414 %, 390 %, 156 %, and 152 %, respectively, compared to the control. Increased microbial activity assists N cycling and availability for plants [2].

Macadamia husk compost application to macadamia trees, therefore, has the potential to improve soil quality and provide additional nourishment to trees, leading to better yields and nut quality.

KEYWORDS:

South Africa, soil quality, macadamia tree, macadamia husk compost.

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GT 07 - 143 - O

CHARACTERIZATION, TRANSFORMATION AND VALORIZATION OF AGRI-FOOD RESIDUES FROM STRATEGIC INDUSTRIES OF THE IBERIAN PENINSULA FOR SUSTAINABLE AGRICULTURE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The growing demand for a more sustainable agriculture, together with the rising cost of mineral fertilizers and the scarcity of P, is driving the search for alternatives based on waste valorization. In this context, the Iberian Peninsula faces numerous challenges that differ between regions. Thus, in the northwest (Galicia, Asturias, North of Portugal), managing the excess of livestock slurry represent a major problem, while in the south a range of residues from the olive industry are accumulated. Considering European policies and strategies, such as the Green Pact and the Circular Economy Plan that promote sustainable waste management that promotes residue valorization, both types of by-products offer opportunities for their transformation into organic fertilizers with high added value. Technologies such as anaerobic digestion or pyrolysis allow the recovery of nutrients and the generation of biofertilizers, contributing to the reduction of dependence on synthetic inputs, in line with the European Union's efficiency and climate neutrality objectives.

In this work, we present the preliminary part of a national initiative (AGRORES-AGROMANURE) that aims to valorize by-products from strategic agri-food industries from northern and southern Spain, transforming residues into quality biofertilizers following a circular economy strategy. This initial part consists of a detailed chemical characterization of different agri-food residues (mainly slurry and olive industry residues) from different Spanish regions. These residues were directly analyzed (fresh) or analyzed after different processes of transformation and stabilization, including anaerobic digestion and pyrolysis. In detail, residue assessment consisted on the evaluation of their quality and fertilizer potential by examining basic nutrient content, toxic potential (heavy metal presence), and advanced analytical techniques such as 13C-nuclear magnetic resonance (NMR) for organic matter and 31P-NMR for phosphorus (P) species.

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GT 07 - 149 - O

ROLE OF SOIL SCIENCE IN SUSTAINABLE NITROGEN MANAGEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Humanity acquired the ability to fix nitrogen (N) artificially in the early 20th century. Crop production has dramatically increased—especially during the Green Revolution of the 1950s and 1960s—through the intensive use of chemical fertilizers and recycled organic matter as N sources. The enhanced capacity of crop production extended to animal feed, thereby also boosting the output of animal products. As a result, the global population has continued to grow, surpassing 8 billion in 2022—five times the 1.6 billion at the end of the 19th century. The artificially fixed N has also been used as a raw material for a variety of products, contributing to economic growth and improved living standards. However, most of the N utilized by humanity is lost to the environment in the form of reactive N (all N compounds excluding stable dinitrogen), causing a wide range of pollution issues, including climate change, stratospheric ozone depletion, air and water pollution, eutrophication, and acidification. In addition, nitrogen oxides created by the combustion of fossil fuels also contribute to N pollution. This situation—where N use is accompanied by N pollution—is referred to as the N issue. Agricultural soils have become N surplus due to the heavy and continuous application of N fertilizers and livestock waste. Conversely, in regions where fertilizers are economically inaccessible, soil N deficit occurs. In natural soils, an increase in atmospheric N deposition due to human activities can lead to eutrophication. All these phenomena threaten soil health by disrupting the nutrient balance. At the international level, efforts are underway to develop a framework of N management that maintain the benefits of N use while mitigating the threats of N pollution. Following the first "Resolution on Sustainable Nitrogen Management" at the 2019 United Nations Environment Assembly, the United Nations Environment Programme established a Working Group on Nitrogen in 2020. This group, with support from experts such as those involved in the International Nitrogen Initiative, is working to develop policy frameworks toward sustainable N management. Soil health is a fundamental basis for food security and ecosystem services, and researchers in soil science are strongly encouraged to actively engage in these efforts. From an interdisciplinary standpoint, comprehensive assessments such as life cycle assessment (LCA) should be promoted. From a transdisciplinary perspective, it is important to foster shared understanding of the N issue, recognize its relevance to individuals, and take concrete actions that also consider the well-being of future generations. The 10th International Nitrogen Conference will be held in Kyoto, Japan, in 2–6 November 2026. It is hoped that this event will facilitate collaboration between soil scientists and other stakeholders toward the development of effective frameworks for sustainable N management.

ACKNOWLEDGEMENTS

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GT 07 - 178 - O

BALANCING FERTILITY AND CONTAMINATION IN THE MEDITERRANEAN: TRACE ELEMENTS AND NUTRIENT DYNAMICS UNDER 12 YEARS OF CONTRASTING SOIL MANAGEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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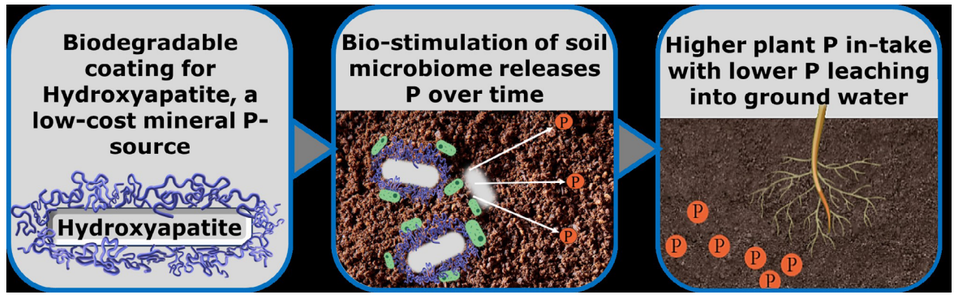
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Soil health is critical for sustainable agriculture, particularly in Mediterranean calcareous soils susceptible to degradation under long-term management. This study assessed the long-term (12 years) impact of tillage (conventional vs. no-tillage), fertilization type (organic vs. mineral), and fertilization dose on soil nutrient dynamics and trace element distribution in a rainfed barley field in Monegros, NE Spain. Soil sampling was performed in the 0-5, 5-10,10-25, 25-50 and 50-75 cm soil layers. Results showed that phosphorus (P) concentrations increased significantly with higher doses of organic amendment, suggesting improved nutrient retention. Potassium (K) was more strongly affected by tillage, with consistently higher levels under no-tillage, likely due to reduced leaching and organic matter conservation. Electrical conductivity (EC) displayed no consistent pattern, though values were generally higher and more variable in conventionally tilled plots, potentially reflecting greater salt accumulation from increased mineralization. Trace elements (TMs), though beneficial for plant growth, can present environmental and human health risks. These elements may accumulate in surface layers or leach from the soil system, leading to contamination, ecotoxicity, and potential entry into the food chain. In this study, trace elements, including copper (Cu), zinc (Zn), sulfur (S), and strontium (Sr), showed a treatment effect related to fertilization, with organic fertilization and higher doses influencing their concentrations. Cu and Zn, which are strongly associated with organic matter and clay, accumulated more in the surface layers, especially under organic treatments. Sulfur and Sr exhibited more mobility, likely due to their ionic forms and affinity with calcium. In contrast, the results for tillage were less consistent, with no clear effect on trace element distribution, suggesting that tillage practices may not significantly influence the mobility or accumulation of these elements in the studied soil. Other trace elements, including lead, cadmium, and arsenic, showed no depth-related variation, indicating limited vertical movement under the studied conditions. These findings support the role of organic amendments and fertilization doses in improving soil fertility and influencing the behavior of trace elements. The element-specific responses highlight the need for tailored management strategies to optimize soil quality and mitigate potential environmental risks in Mediterranean agroecosystems.



GT 07 - 197 - O

POLYSACCHARIDE-COATED APATITE FORMULATIONS: A SYNERGISTIC STRATEGY FOR PHOSPHORUS AVAILABILITY AND REDUCED ENVIRONMENTAL MIGRATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Conventional phosphorus (P) fertilizers are inefficient, prone to fixation or leaching, and contribute to environmental degradation. We developed innovative polysaccharide-coated apatite formulations (Ap@Muci), integrating low-solubility hydroxyapatite with plant-derived mucilage to improve P retention and stimulate microbial solubilization. Two formulations with different mucilage-to-apatite ratios were synthesized via spontaneous adsorption and characterized by thermal and microscopic analyses.

Their performance was assessed through greenhouse trials with wheat and tomato, soil P availability (Olsen P), microbial activity (CO_2 emissions), and leaching tests. P solubilization was further evaluated under sterile and non-sterile conditions to isolate microbial effects.

P leaching from Ap@Muci treatments were an order of magnitude lower compared to triple superphosphate (TSP) and maintained or increased Olsen P over 40 days, while P availability from apatite declined by significantly. In microbial assays, Ap@Muci-high released significantly more P than apatite in the presence of soil bacteria, demonstrating enhanced bioavailability via microbial activation. Soils treated with Ap@Muci showed up to two times higher CO_2 emissions than controls, confirming stimulation of microbial activity.

Tomato plants treated with Ap@Muci-high accumulated more P than those treated with apatite but achieved lower biomass. In wheat trials, Ap@Muci-low resulted in significantly higher biomass than apatite or TSP, highlighting its effective nutrient delivery and environmental advantage. SEM imaging confirmed microbial colonization on Ap@Muci particles, supporting a synergistic interaction between mucilage and mineral P.

Altogether, our findings show that Ap@Muci formulations improve synchronization of P supply with plant demand, reduce losses to the environment, and harness native microbial processes. This work contributes a promising biopolymer-based strategy for sustainable phosphorus management in agriculture.



GT 07 - 208 - O

DESIGN AND PERFORMANCE OF AN INOCULATED WASTE-BASED ORGANIC MINERAL FERTILIZER FOR GRAPEVINES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The transition towards a circular bioeconomy in agriculture requires strategies that integrate waste valorization with agronomic effectiveness and soil conservation. This study demonstrates that the formulation of organic mineral fertilizer (OMF) derived from agro-industrial waste can provide a sustainable alternative of conventional manure to supply specific demands of crops and soils. In addition, the inoculation of this OMF creates a dual-purpose product that combats plant disease and enhances growth promotion. Before formulation, 54 residues within a 150 km radius from Inproyen's facilities were characterized to ensure that the logistics had a low carbon footprint. Seven of these residues were selected based on their nutrient content, contaminant thresholds, and physicochemical synergy to fulfill the demands of crops and soil. The final formulation was composted, sanitized, and inoculated with a microbial consortium (Trichoderma spp., Pseudomonas fluorescens, Azotobacter, Azospirillum, Bacillus subtilis).

Compared to traditional manure, the residue-based formulation significantly increased soil organic matter (28 %), cation exchange capacity (42 %), and available potassium (160 %) after 51 days. Also, soil electrical conductivity decreased by 1.6 dS m^{-1} respect to conventional fertilization. Consequently, shoot growth and bunch weight increased by 13 % and 29 %, respectively. Foliar nutrient concentrations showed increased uptake of P, K, Fe and Zn. Finally, total yield significantly increased by 51 % (from 17.8 to 26.9 Mg ha^{-1}).

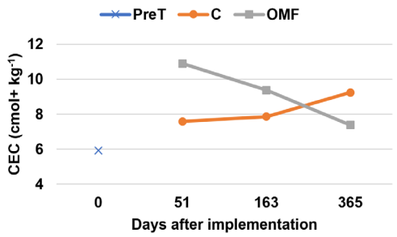
This substantial yield increase with the formulated amendment is due to its specific design, which enables the gradual release of nutrients, as well as to use of an inoculum that combats Cylindrocarpon sp vine disease. The amendment properties comply with EU Fertilizer Regulation 2019/1009 (PFC 3B), offering a viable, environmentally and economically sustainable alternative to conventional fertilizer, providing a benefit of 10,500 USD$ ha^{-1}. Finally, this study aligns with EU Green Deal objectives and circular economy policy, contributing to an improvement of soil health.

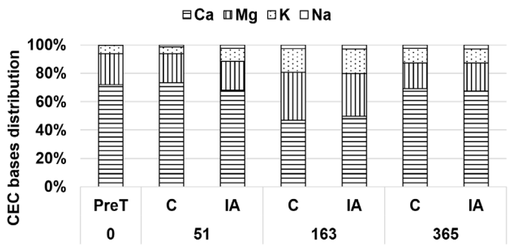
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GT 07 - 219 - O

UNLOCKING MICRONUTRIENT POTENTIAL: IRON (FE) AND ZINC (ZN) BIOFORTIFICATION VIA BIOBASED FERTILIZER STRATEGIES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Applying a circular economy approach for a sustainable agriculture includes the use of biobased fertilizers (BBFs), where nutrients are recycled from different sources as alternatives to conventional mineral fertilizers. In addition to nitrogen (N), phosphorus (P) and potassium (K), BBFs can contain micronutrients such as iron (Fe) and zinc (Zn), whose deficiencies in crops can constrain nutritional quality and contribute to human micronutrient deficiencies. BBFs can promote crop biofortification by enhancing the bioavailability of essential micronutrients. However, micronutrient availability is modulated by soil–plant interactions, organic matter content, and fertilization strategies. An evaluation of BBFs is essential, considering not only their agronomic efficiency for macronutrients, but also their impact on micronutrient bioavailability in crops.

This study evaluated the biofortifying effect of eleven different types of BBFs used as P fertilizer. To this end, a pot experiment was carried out under greenhouse conditions simulating a crop rotation consisting of an initial cycle of wheat (Triticum aestivum L.) followed by sunflower (Helianthus aestivum L.) in two soils with different physicochemical properties. Overall, the application of BBFs improved micronutrient uptake in crops. BBFs as animal and plants mix pellets increased a 6% Fe concentration in wheat grain and a 13% in sunflower seed. Nevertheless, some BBFs showed a negative effect on Fe digestibility by increasing the P:Fe ratio, with olive husk compost and struvite yielding the highest values of this ratio in wheat crop and maize digestates leading to the highest values in sunflower. In contrast, the P:Zn ratio decreased with most of the BBFs evaluated, with horse manure vermicompost and municipal solid waste compost showing the lowest P:Zn ratio.

In the case of wheat crop, sunflower by-product ash resulted in a lower P:Zn ratio in the soil with high Fe oxide content than in the carbonate-rich soil. The application of organic products rich in carbon like composts, increased the Zn concentration in wheat grain by an average of 71% compared to conventional fertilization with superphosphate. This effect may be due to a higher content of fulvic and humic acids, as well as beneficial microorganisms that can improve Zn bioavailability.

According to the results obtained, BBF not only provide essential macronutrients such as P to crops but also enhance micronutrient biofortification, improving the nutritional quality of the crop.

KEY WORDS:

micronutrients, BBFs, biofortification, circular economy



GT 07 - 239 - O

DELISOIL: IMPROVING SOIL HEALTH BY TRANSFORMING FOOD INDUSTRY BY-PRODUCTS IN THE LIVING LAB OF CATALONIA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil degradation is a pressing environmental problem in Europe, currently affecting about 61% of soils1. This degradation undermines agricultural productivity, ecosystem services, and human health. At the same time, large volumes of organic waste from the agri-food sector remain underexploited. In particular, the region of Catalonia (Spain) is characterized as a highly productive and diverse region with soils with a high degree of degradation, mainly affected by water erosion, low organic matter content, and saturated with nutrients due to inadequate slurry management. The DeliSoil project aims to address both challenges by developing sustainable, safe, and effective soil amendments from local food waste. Thus, 4 soil improvers (digestate, compost, biostimulant and biochar) generated from local by-products were evaluated. Each of them was fully characterized and their quality was determined according to specific standards. To evaluate its agronomic performance, a controlled greenhouse experiment was carried out. Fourteen treatments were tested in a completely randomized design with 4 replicates each to amend an agricultural soil of Catalonia with high nutrient content. Wheat (Triticum aestivum) was grown in 3 L plastic pots with controlled temperature and humidity and a 12 h light/12 h dark photoperiod. Treatments included 4 individual soil improvers, binary combinations, a complete combination of all four, a mineral fertilizer (ammonium sulfate), a commercial reference product and an unamended control. Application rates were equivalent to 170 kg N/ha. During growth, key agronomic parameters such as chlorophyll content, plant height and number of stems were recorded. Soil nutrient content at the beginning and end of the experiment and plant tissue were analysed. Regarding the main results, biochar and its combination with compost significantly increased total N in wheat (18.2 and 20.2%, respectively) and the total K uptake (10.8 and 8.1%, respectively). Additionally, the biostimulant and biochar showed the highest microbial respiration, with improvements of 30.5% and 27.8%, respectively. These results highlight the potential of food-based amendments to improve nutrient uptake and support sustainable soil management. DeliSoil will provide a path to the circular bioeconomy by converting organic waste into products that enhance soil health, reduce fertilizer use, and mitigate environmental impacts.

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GT 07 - 252 - O

FROM TAXA TO FUNCTION: PREDICTING METABOLIC PATHWAYS OF AGRONOMIC AND ENVIRONMENTAL RELEVANCE IN HYDROCHAR-AMENDED SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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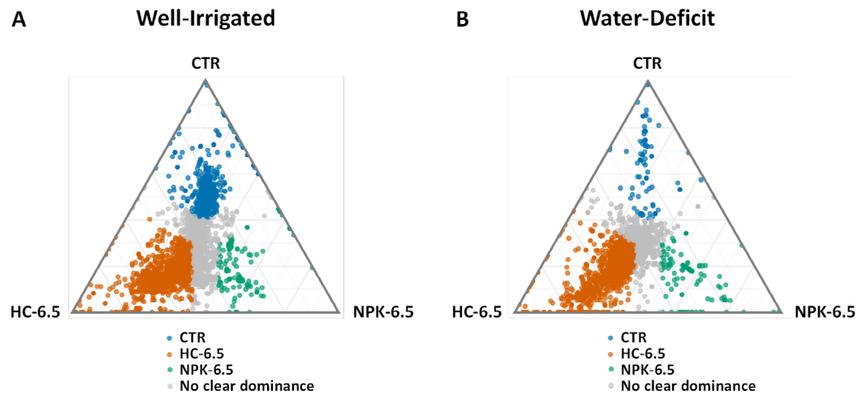
Soil microbial communities play a crucial role in driving key agronomic and environmental processes, including nutrient cycling and plant–soil interactions. In this context, hydrochar-based soil amendments have gained attention for their potential to improve soil quality, yet their impact on microbial functional potential remains poorly understood. Here, we employed a predictive metagenomic approach to assess shifts in microbial metabolic pathways in hydrochar-amended soils after 77 days of sunflower cultivation.

Two hydrochar (HC) application rates were tested, 3.25 t ha^{-1} and 6.5 t ha^{-1} (referred to as HC-3.25 and HC-6.5, respectively), both surface-applied to the topsoil prior to sowing. Given the interest in HC as a sustainable substitute for mineral fertilizers, corresponding NPK treatments with matching nitrogen levels were incorporated for comparative purposes. Additionally, to evaluate the effects of HC under different water availability scenarios, two irrigation regimes were implemented: one representing well-irrigated conditions and the other simulating moderate water-deficit (WD). At the end of the cultivation period, soil samples were collected, and total DNA was extracted for high-throughput sequencing and subsequent bacterial community profiling.

Bacterial functional annotations based on the Kyoto Encyclopedia of Genes and Genomes (KEGG) database were predicted from bacterial 16S rRNA abundance data using Phylogenetic Investigation of Communities by Reconstruction of Unobserved States 2 (PICRUSt2, v2.5.3) in Phyton (v3.9.19).

KEGG Ortholog (KO) enrichment analysis among the most contrasting treatments (CTR, NPK-6.5, and HC-6.5; Figure 1) revealed that soils amended with HC-6.5, regardless of irrigation regime, were potentially enriched in KEGG pathways falling under the categories of Metabolism, Environmental Information Processing, and Cellular Processes. To further explore functional relevance, specific KEGG pathways associated with environmental and agronomic importance or plant growth promotion (PGP) were selected. These were grouped into functional categories including antibiotic biosynthesis, microbial communication (bacteria–bacteria and bacteria–plant signaling), phosphate solubilization, siderophore production, and bioremediation. The HC-6.5 treatment under WD conditions showed particularly strong enrichment in KOs related to these functions when compared to both CTR and NPK-6.5. Under well-irrigated conditions, a similar trend was observed, although with lower predicted abundance of antibiotic-related KOs compared to CTR.

These functional predictions align with previous findings from the same experimental system, where HC-6.5-treated soils not only enhanced plant performance under both irrigation regimes, but also supported greater microbial abundance and activity. These results underscore the potential of predictive metagenomics to uncover functionally relevant shifts in amended agricultural soils.





GT 07 - 283 - 0

EVALUATING INFLUENCE OF MOISTURE IN CONTROLLING RELEASE OF NUTRIENTS IN NOVEL GREEN FERTILISER USING NEUTRON IMAGING AND MUONIC X-RAYS.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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In the UK, agriculture is responsible for 9% of all greenhouse gas emissions, and over 50% are due to the manufacture and use of nitrogen (N) based fertilisers to maintain yields (Defra, 2020). Organo-mineral fertiliser (OMF), which combines organic amendments with reduced amounts of mineral fertiliser, can partly be a solution to tackle this challenge (Sakrabani, 2024).

This works aims to exploit a novel approach for this application, using non-destructive combination of neutron and X-ray computed tomography (NCT and XCT) to assess the physical characteristics of fertiliser pellets such as their porosity distribution.

The OMF samples that were used in this study were derived from anaerobic digestate using crop residue as feedstock.

NCT was performed on the IMAT beamline at the ISIS Neutron and Muon Source, while XCT was performed on the I12-JEEP beamline at Diamond Light Source, representing the first attempt to study the structure of OMF pellets with combined neutron and X-ray imaging techniques.

The neutron radiographies and the reconstructed NCT slices show that the distribution of the dense matter within a pellet is not uniform along the vertical axis (Fig 1b, d). The variations of material packing density within the pellet is important to link the heterogeneity of nutrient distribution when released into soil. High moisture content of the pellet could be revealed by the strong interaction of neutrons with hydrogen, as shown by the neutron measurements (Fig 1 c, d). Additionally, XCT provides valuable information on the internal structure, texture, and porosity, which are important indicators of the pellet's quality and performance (Fig 1e, f) that NCT cannot provide, demonstrating that XCT and NCT are complimentary techniques with regards to pellet imaging.

When using the muonic X-Rays the results indicated that it is possible to determine key elements such as C, N, P, K, Mg within OMF pellets. The data showed that the distribution of these elements was rather uniform within each pellet. This was not as expected and encouraging to know.

Information when using NCT on how densely packed each OMF pellet is important to determine potential for ingress of soil moisture. A very densely packed OMF will be more resistant to ingress of soil moisture than a tightly packed one. Whilst in the field scale context, swelling of OMF pellet is vital for physical breakdown to release nutrients is desirable, the opposite is the case when storing and applying OMF.

This study highlights the potential of using techniques such as NCT, XCT and muon for measuring the variability between OMF samples. In the future, further fine-tuning of these approaches is needed to determine traceability between batches.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the STFC Food Network + and STFC for beam time access for neutron and muon.

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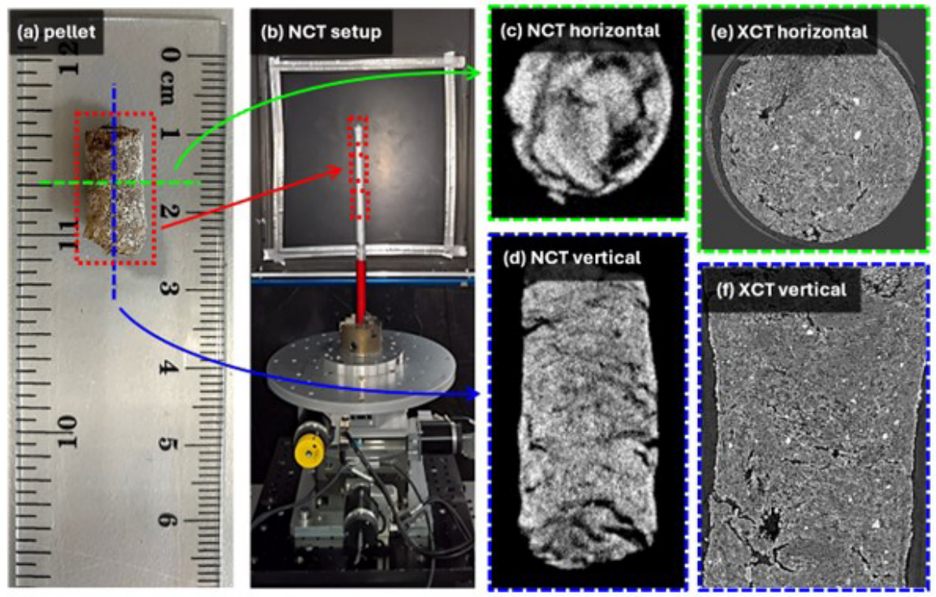


Figure 1: (a) Photograph of one of the imaged fertiliser pellets (ruler for scale), where the dashed lines indicate the NCT and XCT horizontal (green dashed line) and vertical (blue dashed lines) slicing planes; (b) Photograph of the NCT experimental setup, where the pellets (red dashed lines) are inserted into a thin aluminium tube and mounted onto a tomography stage in front of the imaging detector; (c) and (d) Horizontal (green) and vertical (blue) cross-sections taken from NCT reconstructions of the pellet in (a), showing variations in packing density indicating the distribution of pellet constituents; (e) and (f) Horizontal (green) and vertical (blue) cross-sections taken from XCT data of the same pellet, showing detailed internal structure of the pellet's constituents.

GT 07 - 285 - O

LIVESTOCK COMPOST APPLICATION AFFECTS TO CONVERTED UPLAND SOIL PHOSPHORUS CYCLING: ANALYSIS VIA P FRACTION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Recently, South Korea has undergone a decline in rice consumption. So, the trend is cultivating upland crops, such as soybeans, on paddy fields. However, paddy fields and upland fields have been managed through different fertilization and water management methods over extended periods. It is resulting in distinctly different soil chemical properties. One of the main factors is the use of livestock compost, which is known to contain large amounts of phosphorus, potentially leading to phosphorus accumulation and leaching. While there are many studies on phosphorus fraction due to livestock compost in paddy or upland fields, research specifically on converted from paddy to upland is rare. Therefore, this study aimed to analyze the chemical properties and phosphorus fraction of the paddy and converted upland field at different depths to verify phosphorus accumulation and assess the potential for phosphorus leaching. In this study, soil samples were collected from paddy fields and converted upland for five years at depths of 0-20 cm, 20-40 cm, and 40-60 cm. The chemical properties of the soil were analyzed. Additionally, phosphorus fraction, including aluminum phosphorus (Al-P), iron phosphorus (Fe-P), and calcium phosphorus (Ca-P), were analyzed using specific method. In the results, the contents of Total Carbon, Total Nitrogen, Exchangeable potassium, and Available Phosphorus significantly increased with livestock compost application, with a particularly notable increase in Av. P in the topsoil. This increase is attributed to the organic matter and potassium in the manure, suggesting that organic phosphorus in the livestock compost can be mineralized into available phosphorus. Furthermore, the P fraction results indicated a significant increase in forms of Al-P and Fe-P, compared to the relatively Ca-P, when livestock compost was used. Even with the same amount of livestock compost applied to both paddy and converted upland fields, vertical movement of phosphorus was more active in paddy fields than in converted upland fields. This suggests that the use of livestock compost on converted fields can lead to phosphorus accumulation and a greater risk of phosphorus leaching into aquatic ecosystems during heavy rains or monsoons. Through this study, we found that phosphorus accumulation occurs in converted upland field with the use of livestock compost, and there is a potential for leaching of these phosphates to aquatic ecosystem. Therefore, it is necessary to establish appropriate guidelines for the use of livestock compost to manage agricultural fields when converting paddy to upland fields.

ACKNOWLEDGEMENTS

This work was carried out with the support of “National Institute of Crop Science (Project No. RS-2024-00398135)” Rural Development Administration, Republic of Korea.

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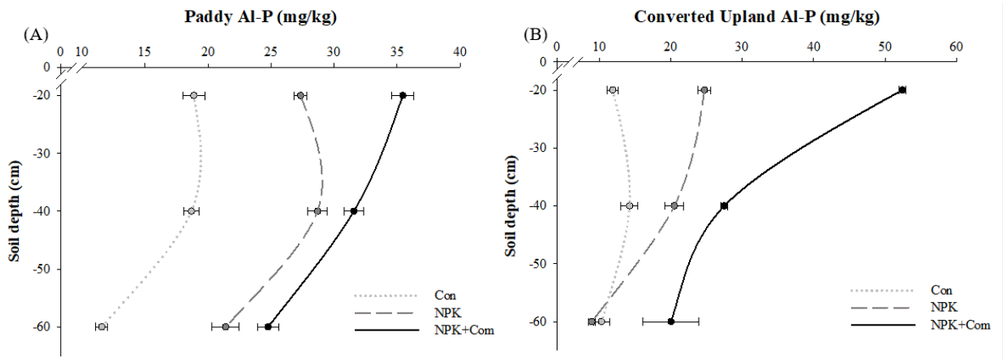


Fig. 1 Aluminum phosphorus amount in each depth of soils. (A): Paddy Field, (B): Converted Upland Field

GT 07 - 290 - O

EFFECTS OF BIOCHAR APPLICATION ON SOIL QUALITY AND CROP YIELDS: RESULTS FROM THE INITIAL FOUR YEARS OF A LONG-TERM FIELD EXPERIMENT IN SWITZERLAND

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The use of biochar in agricultural soils is currently being researched worldwide. Previous research results suggest that biochar has a positive effect on soil quality, particularly through improved soil structure, water holding capacity and nutrient sorption, as well as the potential for carbon sequestration. In order to evaluate the benefits and risks of the application, biochar needs to be tested under field conditions for long-term effects within different climate and soil types. Here we present first results from a long-term field experiment in Switzerland, in which we comprehensively and continuously evaluate the effects of biochar application on soil quality and crop yield.

The trial consists of five agricultural fields in Zürich, Switzerland, with a total area of 10.5 ha. Soil types are clayey loam or loamy clay, and the fields are managed according to organic guidelines and with reduced tillage. Biochar was applied once in spring 2021 according to 8 t/ha on half of the area following a split-plot design. All fields were monitored continuously until at least 2027 for soil carbon (total, organic, carbonate and pyrogenic), total soil nitrogen, pH, cation exchange capacity, aggregate stability, water holding capacity and yields. First results indicate a positive effect of biochar application on soil organic and pyrogenic carbon. However, no effects on the other measured parameters were observed. Therefore, under the given soil and climatic conditions in temperate soils biochar application may be valid to increase long-term organic carbon contents and carbon sequestration. Other propagated effects of biochar application like improved water holding capacity, cation exchange capacity and yields require higher biochar application rates to be significantly affected.



GT 07 - 294 - O

ASSESSMENT OF THE IMPACT OF TORREFIED RAPESEED STRAW APPLICATION ON SOIL MULTIFUNCTIONALITY USING THE BIOFUNCTOOL APPROACH

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Thermochemical conversion of biomass and application of the product to soil is increasingly considered as a sustainable way to manage crop residues in agricultural systems [1]. Pyrolysis and the associated production of biochar has been extensively studied over the last two decades [2,3] but torrefaction (i.e. a thermal process in which biomass is heated to temperatures between 200 and 300°C in the absence of oxygen) and the effects of the resulting torrefied biomass (biotorr) on soil functioning remains underexplored [4]. The aim of this study was therefore to determine the most effective use of crop residues by analysing the impact of two types of biotorr produced at 230 or 280°C compared to intact residues and biochar produced from these residues at 400°C on soil health. We conducted a field experiment to test these amendments over two successive crop cultivations (maize, Zea mays L. and winter wheat, Triticum aestivum). The application rate of biotorr and biochar was 2 t ha-1 equivalent of fresh straw. Soil health, defined as multifunctionality was addressed by measurement of various physical, biological and chemical properties using the Biofunctool method. Additionally, we monitored crop production at three different growth stages. Our results indicated minimal impact of biotorr produced at 280°C on the soil physical, chemical and biological properties, and crop yield. Moreover, it provided higher amounts of stable carbon than fresh residues, and a larger fraction of accessible carbon to soil organisms than biochar, without negatively affecting crop growth or yields. This suggests that torrefaction may be a relevant option for crop residue management. Further research should be conducted through to explore the effects of various application rates and repeated applications over time, with the aim of refining best practices for optimising crop residue management and soil health.

ACKNOWLEDGEMENTS

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GT 07 - 297 - O

PYROLYSIS TEMPERATURE IS NOT A GOOD PROXY OF BIOCHAR PERSISTENCE IN SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The residence time in soils of the carbon constituting biochar is estimated at between several decades and several millennia [1]. The use of biochar as a soil amendment for climate change mitigation is the subject of intense research activity. To accurately estimate the quantity of sequestered biochar carbon, it is necessary to know its composition and its persistence in soils on the appropriate time scale. As long-term persistence cannot be measured directly, many authors have suggested the use of proxies based on the physico-chemical characteristics of biochars [2,3]. These characteristics depend on production conditions and feedstock biomass [3]. The IPCC's authors have thus proposed a categorical model linking the 100-year persistence of biochars (Fperm) and maximum pyrolysis temperature (HTT) [4]. It was revised by Woolf and colleagues in 2021, based on additional data [5]. We question the reliability of these models [6]. As it is not possible to directly measure the 100-year persistence of biochar, we have chosen to re-examine the relationship between biochar production conditions, in particular the maximum pyrolysis temperature, and its physico-chemical characteristics. We analysed data on 1230 biochars and showed that the oxygen to carbon (O:C) and hydrogen to carbon (H:C) ratios (two indicators of persistence) were mostly affected by HTT and pyrolysis duration, except for biochars derived from plastic waste and sewage sludge. However, HTT was not measured accurately enough to precisely predict H:C, let alone persistence. Based on equations available in the literature, we calculated Fperm from HTT and from H:C across the entire dataset and showed that the two values differ strongly. The sign and magnitude of the error depended on the equation used, and the dispersion was often large. This could lead to improper compensation of carbon emissions and wrong reporting of carbon sinks in national carbon accounting schemes. We advise against using models based on unreliably assessed production parameters such as HTT to predict biochar persistence in soils.

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GT 07 - 305 - O

MITIGATING YIELD DECLINE IN CONTINUOUS WINTER WHEAT ROTATIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Winter wheat is one of the most important crops worldwide. Therefore, farmers have been increasing the share of WW in their crop rotations, while a large proportion of wheat is grown continuously in the same field. However, self-succession of WW leads to yield decline, which is often attributed to the soil-borne fungus Gaeumannomyces graminis var. tritici (take-all). This decline is observed even in years without pronounced take-all presence in the soil. Changes in the microbial community composition in the rhizosphere have been previously suggested to modulate the yield decline in continuous wheat rotations. Two experiments are presented, aiming to identify suitable options for mitigating this yield decline phenomenon. In both experiments two rotations were contrasted i.e., wheat after oilseed rape and wheat after wheat. In the first experiment, we assessed the potential of green-waste compost to promote the yield of continuous wheat in an outdoor mesocosm experiment. A multiple isotopic approach was followed. 13CO2 pulse labeling was used to measure C allocation above and belowground, 15N-labeling was used to trace plant N uptake, while D2O and 18O-enriched water were injected into two soil layers and traced into plant biomass. We found that compost significantly mitigated yield losses in the continuous wheat rotation and this was strongly related to enhanced allocation of freshly assimilated C into plant biomass. Compost-treated continuous wheat took up more of the applied 15N-fertilizer compared to the untreated control and compost reduced the contribution of subsoil to plant water uptake. Compost increased soil microbial biomass and the supply of plant-available nutrients which stimulated root growth and 15N uptake. In the second outdoor experiment with temperature-regulated rhizotrons, we tested the effect of seed-inoculation with Bacillus pumilus on early growth of continuous wheat. We found that B. pumilus induced changes in root growth and compensated for the early growth reduction in continuous wheat, without influencing the bacterial and archaeal communities in the rhizosphere. Collectively, both studies provide evidence in support of compost and beneficial rhizobacteria in promoting yield increases in wheat monocultures.

GT 07 - 309 - O

ORGANIC-BASED FERTILIZERS FOR SUSTAINABLE VINEYARD MANAGEMENT: EFFECTS ON SOIL BIOCHEMISTRY, MICROBIOME AND CARBON STOCK

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The decline of organic matter (OM) in agricultural soils is a major challenge affecting soil quality, fertility, and overall health. The use of organic-based fertilizers (OBFs), such as compost and sewage sludge, provides a practical solution to restore soil OM levels and nutrients in line with sustainable agriculture practices and the principles of a circular economy, where waste is transformed into a valuable resource. Indeed, these materials can serve as sustainable alternatives to mineral fertilizers, thereby improving soil productivity and quality [1].

In this study, three OBFs were applied since planting (2019) in an experimental vineyard in Northern Italy (Cadriano, Bologna). The OBFs included Municipal Organic Waste Compost (MOWC), Sewage Sludge Compost (SSC), and 'Plasters' from the alkaline hydrolysis of Sewage Sludge (SSP).

The study aimed to investigate the effects of these OBFs on soil biochemistry, soil carbon (C) sequestration process, and stock, together with variations in the soil microbiome. Several soil analyses have been carried out, including the measurement of soil hydrolytic and oxidative enzymatic activities, carbon and nitrogen pools (i.e., microbial, extractable, and total) content, microbiome composition by 16S rRNA gene sequencing, and the determination of a multifactorial Soil Quality Indexes (mSQI).

The results showed that MOWC and SSC compost, as a source of recalcitrant organic carbon, significantly promoted soil biodiversity and increased microbial biomass. Conversely, SSP, a more readily degradable source of carbon and nitrogen, induced an increase in the extractable nitrogen content.

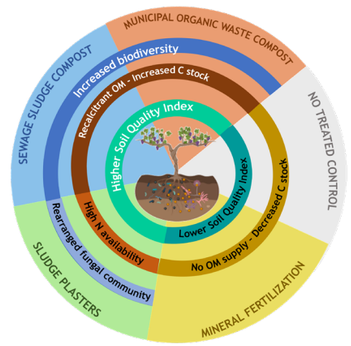
The OBFs, especially MOWC, greatly promoted carbon stock in the soil, even in deeper layers (0.3-0.5 m depth). The mSQI was highest with MOWC and SSC indicating a higher overall soil quality. This improvement could be linked to increased C inputs and stocks, which act as a nutrient reservoir, gradually releasing nutrients and reducing environmental losses.

The three OBFs did not act as microbial inoculants. Instead, the two composted OBFs stimulated specific autochthonous microbial populations and had a profound and diverse effect on the cumulative fungal and bacterial network of microbial interactions. On the other hand, due to its higher carbon and nitrogen availability, SSP resulted in a profound rearrangement of the fungal population.

These results confirm that OBFs can be a valuable alternative to mineral fertilization. Specifically, composted matrices (I.e., MOWC and SSC) act as soil amendments while SSP showed a behavior similar to that of mineral fertilizer with the advantage of promoting carbon sequestration. A study of their use with different crops and with an integrated approach should be useful for a greater definition of their practical application in soil.

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GT 07 - 322 - O

REVITALIZING SANDY SOILS: ORGANO-MINERAL INPUTS ENHANCE DROUGHT RESILIENCE IN WHEAT AND MICROBES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Increasing drought conditions severely limit nutrient cycling and wheat production in sandy soils. Organic and mineral amendments such as compost (CM), sheep manure (SM), and bentonite clay (BN) have potential to improve drought resilience. Research on how different rates and types of organo-mineral amendments affect wheat and microbial drought resilience in sandy soils remains limited. We aimed to understand how CM, SM, and BN interact to improve wheat drought resilience in four experiments. In Experiment I, three drought-sensitive wheat varieties (Trojan, Cobra, and Gregory) were screened under five drought levels. Based on aboveground and belowground traits, and soil nutrient levels, Trojan, the best performer under drought, was selected for Experiment II. In Experiment II, organic amelioration of drought was assessed using CM or SM at three application rates (10, 25, or 40 g kg-1) at 75%, 50%, and 25% of water holding capacity (WHC). Under drought (25% and 50%WHC), CM and SM at 25 g kg-1 had the greatest increase in aboveground (20%), belowground (70%) biomass, and photosynthetic rate (42%), but decreased specific root length (34%), relative to the unamended control. Across water levels, CM and SM increased N and P uptake, $NO3^-$-N, available P, microbial biomass N (MBN) and P (MBP), whilst decreasing $NH4^+$-N and mineral N, with greater effect at 25 g kg-1. In Experiment III, moderate rate (25 g kg-1, eq. 37.5 t ha-1) of CM and SM alone (100%CM, 100%SM) or combined (50%CM+50%SM) was applied to assess wheat yield and soil water retention at 75% and 35%WHC during critical vegetative and reproductive growth stages. At 35%WHC, 100%CM and 50%CM+50%SM showed greater increase in yield and physiology during the vegetative than the reproductive stage. Generally, N uptake, $NO3^-$-N, and MBN were greater with 100%CM, P uptake, available P, and MBN with 100%SM, and moisture retention and plant available water with 100%SM and 50%CM+50%SM, relative to control. In Experiment IV, individual and combined effects of micronized (< 1µm) SM (25 g kg-1) and BN (3% w/w) were investigated on soil moisture dynamics, rhizosphere microbial communities, and wheat productivity under 75% and 35%WHC. Synchrotron-based micro-CT analysis was used to visualize and quantify amendment-induced changes in soil porosity and microstructure. We hypothesize that amendment-driven increase in microporosity will enhance water retention in sandy soil, particularly at 35%WHC, leading to improved nutrient availability, microbial activity, and wheat yield. Overall, CM-, SM-, and BN-induced wheat drought resilience was likely due to improved nutrient availability, enhanced water retention capacity, and stimulation of microbial activity in sandy soils. The moderate rate (25 g kg-1, eq. 37.5 t ha-1) of CM and SM, alone or combined with BN, could substantially mitigate the negative effects of drought on wheat production, nutrient cycling, moisture retention, and microbial dynamics in sandy soils.

GT 07 - 336 - O

ROOTED IN EMISSIONS: UNCOVERING GHG FLUXES FROM WINTER WHEAT UNDER ORGANO-MINERAL FERTILISATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Can we nourish crops without harming the climate? Agriculture feeds the world—but it's also fed by mineral fertilisers, which account for up to 50% of nutrient inputs and contribute ~2% of global greenhouse gas (GHG) emissions through energy-intensive production (1). On top of that, emissions during application, nutrient losses, and declining soil health call for urgent innovation in fertiliser strategies (2). This research is the first of its kind to provide GHG flux data from organo-mineral fertilisers (OMF) in lysimeters.

This study investigates OMFs as a sustainable alternative to conventional mineral fertilisers. By blending organic matter (digestate) with mineral nitrogen (ammonium nitrate) via a carbon capture-enhanced process, OMFs aim to improve nutrient efficiency, reduce nitrogen losses, and enhance soil health. Despite growing interest, their real-world GHG emission profiles—particularly for N_2O, CO_2, CH_4, and NH_3—are still underexplored.

Using a glasshouse lysimeter experiment (24 units, 220 L each), winter wheat was grown under various fertilisation treatments: 45%, 60%, 75%, and 90% OMF rates, alongside 100% mineral and unfertilised controls. GHG fluxes were measured using a Gasmet GT5000 Terra FTIR analyser and processed via Calcmet Professional software, with calibration via nitrogen gas. The experiment has been replicated over three successive growing seasons, strengthening the validity of the findings and enabling seasonal comparisons. Further investigation is currently underway to explore long-term impacts and mechanistic pathways.

The results showed that CO_2 fluxes from OMF ranged from 0.4 to 1 g m^{-2} h^{-1}, comparable to mineral fertiliser levels. Interestingly, CO_2 emissions were higher in OMF treatments, especially at the 45% rate, likely due to enhanced microbial respiration from carbon-rich organic inputs and adjustments in the soil C:N balance. NH_3 emissions responded sharply to fertiliser timing, with significant peaks (> 0.003 g m^{-2} h^{-1}) post-application. N_2O emissions displayed a fluctuating pattern, peaking during application and tapering off toward crop maturity, reflecting interactions between soil moisture dynamics and root development across growth stages.

Whilst in this study, OMF emissions are not consistently lower than those from mineral fertilisers, ongoing work is exploring nutrient release mechanisms and above-ground crop responses at key growth stages. The current findings suggest that OMFs can match conventional fertilisers in GHG performance while contributing organic matter that supports soil health. However, further research is required to fully understand their long-term contribution to soil ecosystem services.

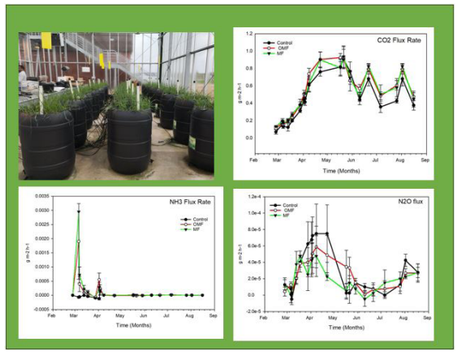
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GHG emission profile from wheat growth in lysimeters- A glasshouse study



GT 07 - 342 - O

CHITIN AMENDMENT IN SOIL: EFFECTS OF CHITIN SOURCE AND PARTICLE SIZE ON SOIL PHYSICAL PROPERTIES UNDER VARIABLE ENVIRONMENTAL CONDITIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 05. SOIL HYDROLOGY & EROSION

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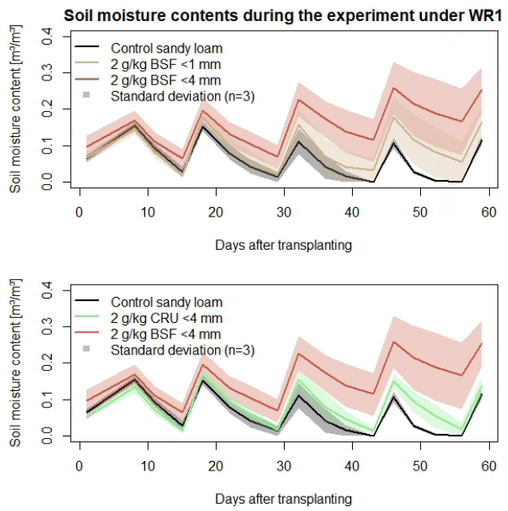
Climate change is increasing the frequency and severity of droughts in Western Europe, posing significant risks to farmers. Soil amendments that improve moisture retention offer a potential mitigation strategy. This study investigates chitin, the second most abundant natural polymer, derived from two sustainable sources: Black Soldier Fly (BSF) larvae grown on organic waste, and crustacean shells (CRU), a fishery byproduct. The potential of chitin to increase soil moisture retention was already proven in a previous study in our lab. This study explores the influence of the source and particle size of chitin on soil physical, selected chemical properties and lettuce yield under diverse environmental conditions.

A pot experiment was conducted to evaluate the effects of various chitin-based treatments. Chitin was sieved into three particle size fractions (<4 mm, <2 mm, and <1 mm) and applied at two rates (1 g/kg and 2 g/kg). In addition, chitin was mixed with compost to create a chitin-enriched compost (ChEC), a pure compost (PC) and unamended control (UC) were also included. Three water regimes were tested: a cyclic drought (WR1), a consistently wet regime (WR2), and a regime with a prolonged dry period (WR3). Treatments were applied to a sandy (S) and sandy loam (SL) soil, each replicated three times. Lettuce was grown on the treated soils for eight weeks. The moisture contents were followed up twice a week. At harvest, crop yield and the soil moisture retention curves were determined.

All treatments under SL increased the soil moisture content during the experiment. However, a significant increase was observed only in the PC and BSF treatments under WR1, where moisture content more than doubled relative to the UC. Only treatments with particle size <4 mm and <2 mm significantly improved the soil moisture content, while the <1mm treatments showed no significant effect. In the S treatments, all chitin treatments under WR1 tended to reduce moisture content, although this trend was not significant. Under WR2, moisture content doubled relative to the UC with the application of PC and BSF treatments. Remarkably, although both PC and pure BSF treatments individually increased soil moisture content, their combination, ChEC, did not result in a significant increase.

The particle size significantly affected the wet end of the soil moisture retention curves, while the source of chitin had a significant impact between pF equal to 2 and 3. Both the water regime and soil type significantly influenced all measured points along the soil moisture retention curves. Lettuce yield was significantly affected by the water regime, soil type and the chitin dose.

These findings highlight the importance of environmental conditions, particularly water regime and soil type, in shaping the effectiveness of chitin treatments on soil physical properties and yield. Treatments with larger particle sizes and BSF-derived chitin delivered the most favorable results.



GT 07 - 354 - O

IMPACT OF PIG SLURRY DIGESTATE ON SOIL QUALITY: A 6-YEAR STUDY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Spain is one of the largest pig producers worldwide, which leads to an important availability of biowastes. Its anaerobic digestion treatment is currently under development in Spain. The aim of this study was to evaluate the performance of digestate as fertilizer in a Mediterranean rainfed cereal system.

Six fertilization treatments and a control (C) were assessed over six years in a completely randomized blocs design with three replications. The organic fertilizers were: compost sewage sludge (CSS) at sowing, pig slurry (PS) and digested pig slurry (DPS) at top-dressing. The mineral (M) one was a nitrogen (N) top-dressing application. The last treatment was the residual effect of a CSS (RE-CSS) applied at an average rate of 351 kg N ha-1 four years ahead this trial. The average effective applied rates were 83.3 kg N ha-1 as M, 77.8 as PS, 153.6 as DPS and 145.3 as CSS. The parameters analysed at the end of the trial included: plant-water holding capacity (WHC) as the difference between field capacity and permanent wilting point using intact soil cores till 10 cm, granulodensimetric fractionation of SOM at 0-10 cm [1], and microbial biomass carbon (MBC) by the fumigation-extraction method [2] to 15 cm and water stable aggregates (WSA) and mean weight diameter (MWD) to 10 cm.

CSS reached the largest yield (Figure 1.A) probably due to its higher WHC (Figure 1.B). CSS and RE-CSS showed a higher capacity to increase the soil C content (figure 1.C). DPS had the highest MBC probably due to its lower amount of pathogenic or inhibitory microorganisms than PS, and its lower proportion of recalcitrant carbon as compared to CSS (Figure 1.D). Higher carbon application led to a not significant increase in WSA and MWS (Figure 1.E). Fertilization did not cause nutrient deficiencies (except for the C treatment).

Yield differences were due to soil quality improvements by fertilization. DPS could be incorporated in the fertilization strategy yielding as much as M and PS while enhancing soil health. The fertilization strategy in Mediterranean areas with low annual precipitation (<400 mm) should not be based only on mineral fertiliser as this would lead to soil quality decline. However, the DPS and CSS treatments supplied more nitrogen than the crop required; hence, in semi-arid cereal rainfed cropping systems (<400 mm), organic fertilizer should be applied based on crop nutrient needs to minimize environmental impacts.

ACKNOWLEDGEMENTS

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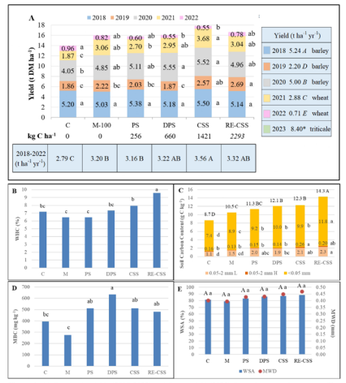


Figure 1. A) Crop grain yields (2018-2022) and forage yield (2023) for each year and treatment. The average yield on the right of the graph shows the year effect (*year 2023 was assessed separately because its use was for forage due to the drought). Italic capital letters show significant differences between years. The mean yield on the shaded bottom of the graph shows the treatment effect; capital letters show significant differences between treatments. The vertical stacked bars show the cumulative yield and the yield per year and treatment. Lowercase letters show significant differences between treatments within the same year. The number under the treatment code shows the average carbon applied per treatment. Note that the total carbon applied in the RE-CSS is in italics as it was applied four years ahead of this trial. **B)** water holding capacity (WHC) per treatment. Lowercase letters show significant differences between treatments. **C)** Soil caron content for 0.05-2 mm Ligh, 0.05-2 mm Heavy and <0.05 mm fractions. Lowercase and uppercase letters show significant differences between treatments for each fraction and for the sum of fractions, respectively. **D)** Microbial biomass carbon (MBC) per treatment. Lowercase letters show significant differences between treatments. **E)** water stable aggregates (WSA) and mean weight diameter (MWD) per treatment. Capital letters refer to WSA and lowercase letters to MWD, both show significant differences between treatments. In all cases a t-Student test was performed at p<0.05.



GT 07 - 373 - O

POROUS BIOCARBON AS A SCAFFOLD FOR SLOW-RELEASE NITROGEN FERTILIZER

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Sugarcane is a key agro-industrial crop in Australia, contributing nearly $2 billion annually to the national economy. However, the sector faces growing challenges such as fertilizer leaching and ineffective green waste management1. These issues highlight the need for sustainable, organic alternatives to conventional fertilizers. Porous biocarbons, due to their high surface area and chemical stability, has have recently emerged as promising support materials to load and release nutrients Additionally, using agricultural biomass waste like sugarcane leaves to produce porous carbon supports sustainable waste management and adds value to agricultural by-products2. In this study, sugarcane leaves were used as the primary biomass feedstock to synthesize carbon materials for application as a slow-release nitrogen fertilizer. The leaves were initially pyrolyzed to produce non-porous carbon (NPC), which was then chemically activated with KOH at 800 °C to induce porosity (PC), predominantly in the microporous domains. Further, urea was incorporated into both NPC and PC as the nitrogen source, and the materials were pelletized using molasses as a natural binder to create a slow-release formulation. Characterization revealed a significant increase in surface area from 17 m²/g in NPC to 3100 m²/g in PC with a 3:1 KOH-to-NPC ratio (Fig. A). CHNS elemental analysis confirmed successful nitrogen loading, with nitrogen content reaching 29% in NPC and 33% in PC using a 4:1 urea-to-NPC/PC ratio (Fig. B). SEM elemental mapping and EDS analysis indicated a uniform nitrogen distribution throughout the carbon matrix (Fig C-F). These findings suggest that increased porosity significantly improves nitrogen retention and distribution within the carbon structure. When tested via column perfusion method, the release of nitrogen was found to be slow and controlled over a duration of 72 h. Overall, this study demonstrates the potential of sugarcane-leaf-derived PC and NPC as sustainable slow-release nitrogen fertilizers, offering dual benefits of enhanced nutrient efficiency and improved biomass waste utilization in sugarcane farming systems.

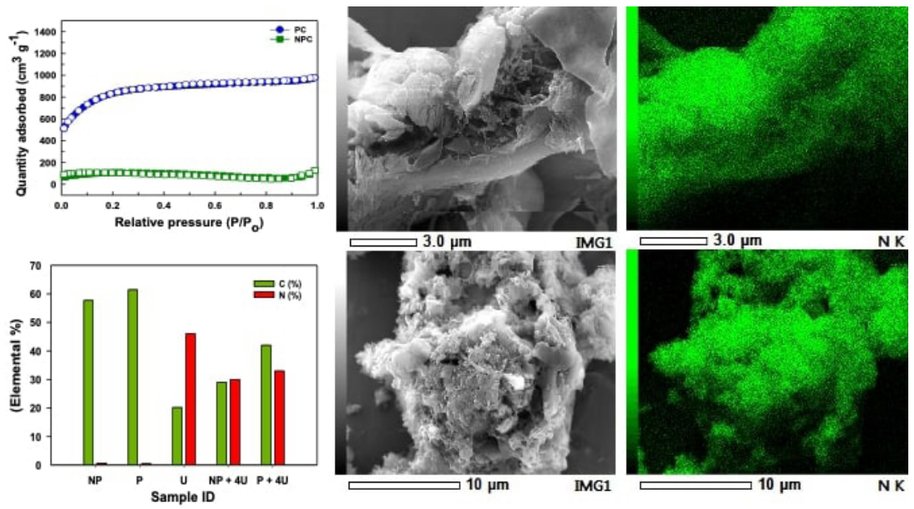
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GT 07 - 393 - O

UNLOCKING THE POWER OF COMPOST MICROBIOMES FOR SUSTAINABLE AGRICULTURE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Achieving sustainable agricultural production demands innovative strategies that simultaneously enhance soil functions, restore fertility, and boost crop productivity. Bio-based fertilizers (BBF), particularly those derived from recycled organic waste, offer an eco-friendly alternative to synthetic inputs. Beyond supplying essential nutrients, compost harbors microbial communities that can drive nutrient cycling, improve soil quality, and promote plant growth. Yet, the specific contribution of compost-associated microbiota to plant development remains largely underexplored. To address this gap, we conducted a greenhouse pot experiment to evaluate how the compost microbiome influences the successful establishment and growth dynamics in alfalfa (Medicago sativa). Alfalfa grown with unsterilized compost showed significantly enhanced performance, including shoot and root length, higher aboveground biomass, expanded leaf area, and increased stomatal conductance compared to those receiving sterilized compost. In addition, we analyzed shifts in microbial communities and their relationships with soil physicochemical properties through the experiment. Our findings underscore a rich and diverse compost-derived. Microbial community plays a critical role in promoting plant growth and highlights its potential as key agents in sustainable, microbe-driven agriculture. This study also reinforces the value of recycled organic amendments not just as nutrient sources, but as a living input capable of revitalizing soil-plant-microbe interactions in sustainable cropping systems.

ACKNOWLEDGEMENTS

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GT 07 - 401 - O

FERTILIZER ENRICHED BIO-BASED MULCH FILMS INCREASE NITROGEN AND PHOSPHORUS AVAILABILITY AND STIMULATE SOIL MICROBIAL BIOMASS AND ACTIVITY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Plastic mulch films are widely used in agriculture to enhance crop productivity and to control weeds. However, their impact, due to the use of non-biodegradable materials such as polyethylene, poses a growing environmental risk. In fact, these films can persist in the soil for several years after use, contributing to plastic pollution and hindering sustainable agriculture [1]. Recently, Ciaramitaro et al. [2] developed an innovative bio-based mulch films composed of carboxymethyl cellulose (CMC), chitosan (CS) and sodium alginate (SA). These films have also been enriched with monoammonium phosphate (MAP) to be potentially released during their degradation thus supplying N and P to soil. This study aims to evaluate the impact of N and P enriched bio-based films on N and P pools dynamics and microbial biomass, activity and community structure. For this purpose, two types of films, both with and without MAP-enrichment, were mixed with the soil at 0.1 % (w/w) ratio to simulate field conditions. Soil samples were analyzed at 30, 60, 90 and 120 days after film application to assess changes in above variables. The results showed that MAP-enriched films significantly increased the concentrations of available nitrate and phosphate by up to 76 % and 72 %, respectively. All four film types increased microbial biomass C and N, while enhanced β-glucosidase and N-acetyl-β-d-glucosaminidase activities indicated some biodegradation of CMC and CS. The degradation of the biopolymers was further confirmed by lipase activity, which was on average 79 % higher in the film-amended soils. Moreover, films influenced the microbial community structure, favoring the growth of bacteria, particularly Gram positive, over fungi. Overall, these results suggest that these innovative bio-based films are promising candidates for sustainable agricultural practices.

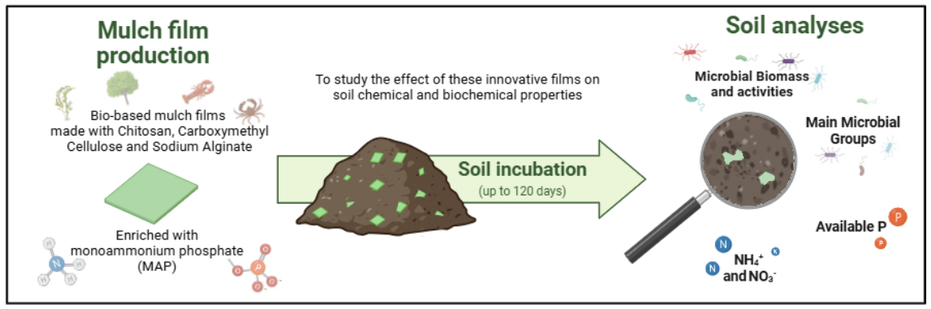
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GT 07 - 407 - O

PHOSPHORUS DYNAMICS AND PLANT RESPONSE WITH BIOAMENDMENTS IN CONTRASTING SOILS: INCUBATION EXPERIMENTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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In the past century, agriculture has difficulties to keep up with population growth due to soil degradation and nutrient loss. To address this, sustainable practices like using recycled organic bioamendments are being promoted to restore soil health and reduce reliance on synthetic fertilizers. However, how these bioamendments work across soils with varying properties remains unclear. To address this gap, we conducted a 6-month incubation experiment to evaluate the effects of 6 different bioamendments, previously composted: olive mill pomace (OMP), Solid Urban Residue (SUR), digestate (DIG), vermicompost (VC), commercial plant residue (CPR), and struvite (STR), applied to two contrasting soil types, a Vertisol and an Inceptisol, typical soils in Spain. The bioamendments were applied basing on their P content, to achieve a uniform P addition of 30 mg P kg^{-1} soil. Treatments also included a negative control (no amendment) and a positive control, a synthetic P fertilizer (di-ammonium phosphate, DAP). A total of 16 treatment combinations (2 soils × 8 treatments), each one with 3 replicates (48 pots; each pot 260 g of soil), were incubated in an isotherm room under darkness. The pots were kept near field capacity. During (and after) the incubation Olsen-P was monitored, with post-incubation analyses such as soil enzyme activities. The treated soils were subsequently used in a pot experiment to evaluate plant development (leaf chlorophyll index and plant biomass) and P uptake. The availability of P was also measured at the end of the pot experiments.

Results showed that the bioamendments differed in the quality of their organic matter composition, influencing mineralization rates and subsequent nutrient release. Notably, SUR and DIG led to significant increases in Olsen-P compared to the control, which was attributed to their differing organic matter characteristics (more labile), while OMP had more recalcitrant components that slowdown its decomposition rate, hence, nutrients releasing. These differences were reflected in plant growth and productivity. Soil type also played a critical role, with Vertisol showing a reduced response to the amendments due to its tendency to immobilize nutrients (high carbonates and clay content).

In conclusion, composted bioamendments present a promising approach for soil and agriculture in an environmentally sustainable way. However, the selection of bioamendments should be tailored to the specific chemical characteristics of the amendments and the soil type to maximize their effectiveness.

ACKNOWLEDGEMENTS

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GT 07 - 411 - O

ORGANIC AMENDMENTS FROM RESIDUES FOR SOIL HEALTH, LONG TERM CARBON STABILITY AND NUTRIENT RECYCLING

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil degradation is a critical challenge to global agriculture, diminishing productivity, compromising food security, and exacerbating environmental stress in climate-sensitive regions, which elevates dependence on mineral fertilizers. As intensive traditional farming reduces the organic matter affecting soil physical properties too, circular solutions are urgently needed to regenerate their health and functionality [1]. This study investigates how improved organic amendments—produced from agricultural, forest, and livestock residues—can be harnessed to restore soil quality, enhance physical properties, stabilize carbon, and recycle essential nutrients. Thus, biochar derived from olive mill waste and other biomass residues, composts from green and agricultural residues, and anaerobic digestates from livestock manure, have been applied individually and in combination on both acidic and calcareous soils to assess their impact on soil structure, porosity, water retention, carbon dynamics, and plant performance. Results show that biochar application improved soil aeration and water holding capacity while significantly increasing long-term Carbon content. When co-applied with compost, synergistic benefits were observed, including enhanced microbial activity and nutrient availability. However, the application of liquid amendments such as compost tea required careful dosage, as excessive concentrations negatively affected early plant growth.

Field trials in Mediterranean orchards under limited irrigation revealed that these organic formulations improved soil water-holding capacity, photosynthetic efficiency, and soil organic carbon content [2]. By transforming organic residues into tailored amendments, this approach supports the EU's circular bioeconomy goals and provides a robust strategy for sustainable soil management. Ultimately, organic amendments from residual biomass represent a promising pathway to regenerate soil health, increase soil carbon stocks, and close nutrient cycles in agroecosystems.

ACKNOWLEDGEMENTS

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GT 07 - 441 - O

FROM ASHES TO OAKS: HOW LONG-TERM EFFECTS OF BIOCHAR ON BIOPHYSICOCHEMICAL SOIL PROPERTIES MAY AFFECT SURVIVAL AND GROWTH OF QUERCUS PETRAEA IN A FOREST RESTORATION PROJECT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Reforestation is essential for climate change mitigation, ecosystem restoration and the prevention of biodiversity loss. However, its success is often constrained by poor soil conditions. This study investigates how the long-term effects of co-composted biochar on soil biophysico-chemical properties explain survival and aboveground performance of sessile oak (Quercus petraea) in a reforestation site in west-central Germany.

150 young saplings germinated in untreated Palatinate arable soil and grown for two years were out-planted in one of three soil treatments (local forest soil, compost, and biochar-enriched compost). Several growth parameters (stem diameter and length, leaf area) and survival rates were assessed in three surveys during one year. The data revealed that co-composted biochar treatment negatively affected plant growth but increased sapling survival in contrast to compost treatment. Surprisingly, saplings grown in control soil showed higher survival and growth rate than those grown in treated soil.

In a follow-up study on the biophysicochemical soil properties around the oak sapling, we hypothesize that both compost and co-composted biochar should improve soil conditions for the samplings by increasing soil water holding capacity, soil structural stability and soil microbial activity. We further suggest that compost-induced increments in nutrient availability and electrical conductivity which may have affected plant performance, e.g., via osmotic stress, were partially sorbed on biochar, thus decreasing stress for the saplings. We finally suggest that biochar decreased soil wettability, which in turn may have reduced growth of saplings in dry periods.

The biological parameters from the saplings and the biophysicochemical properties of the amended soils are analysed in a comprehensive way to test our hypotheses. The interdisciplinarity of our study helps to understand why the application of soil conditioners can have mitigated effects on biological parameters. Finally, we recommend to consider the effect of further soil amendments, such as superabsorber, critically by analysing pedological and biological variables.

ACKNOWLEDGEMENTS

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GT 07 - 473 - O

PHOSPHORUS RELEASE BEHAVIOR FROM SEWAGE SLUDGE MOLTEN SLAG AND ITS AVAILABILITY TO PLANT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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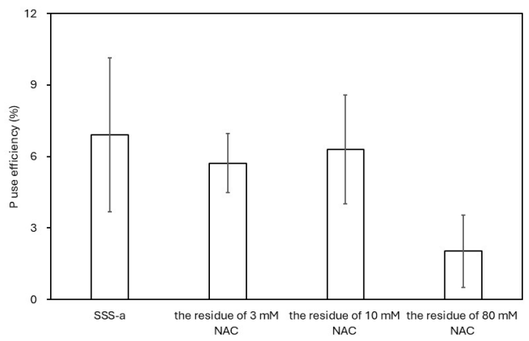
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In sewage sludge treatment, composing, combustion, and melting are utilized for detoxification, volume reduction, and sludge recycling. Melting treatment is a process in which sewage sludge is melted at a high temperature of around 1400ºC. The molten material is then cooled and solidified as the molten slag. The molten slag is environment-friendly material because the toxic metal(loid)s are removed by the volatilization. Furthermore, one of the potential utilization of the molten slag is for agricultural purposes because of its high phosphorus content. However, it is often unclear how phosphorus is released from the molten slag and supplied to the plants. Therefore, this study aimed to clarify the mechanism of phosphorus release and phosphorus fractions uptaken by the plant in the sewage sludge molten slag. Two types of sewage sludge were subjected to the melting treatment for the production of the molten slag in the laboratory (hereafter, SSS-a and SSS-b). The amounts of phosphorus released were evaluated using 1, 3, 10, and 80 mM neutral ammonium citrate (NAC) solutions over the shaking time. The residues after the extraction were collected to calculate the weight loss during the test. In addition, the surface structure of the molten slag and extracted residue was observed by SEM and the crystal mineral composition was analyzed by XRD. In order to clarify which the phosphorus fraction is utilized by the plant, a cultivation test was conducted using the molten slag and their residues after the extraction. After the cultivation test, plant biomass and the amounts of phosphorus uptake were determined. At the low NAC concentrations, the % of phosphorus release were comparable with the % of weight loss during the extraction. At the high NAC concentrations, however, the % of phosphorus released exceeded the % of weight loss of the molten slag. Furthermore, the % of phosphorus released depended on the sewage sludge species. Apatite was identified from the SSS-a, but not the SSS-b by XRD. The extraction of 10 mM or more NAC resulted in the pore structure on the surface of the residue by SEM observation. SSS-b had an amorphous structure and did not have the pore structure. These results suggest that apatite is dissolved from SSS-a at higher NAC concentrations while phosphorus in both SSS-a and -b is readily released at higher % than those of slag dissolution itself. In the cultivation test, the % of the phosphorus use efficiency decreased with the residue after the extraction with the residue after the extraction with the higher NAC concentrations at 6.9% for SSS-a, 6.3% for the residue after the 10 mM NAC extraction, and 2.0% for the residue after the 80 mM NAC extraction. Therefore, the phosphorus fraction that extracted between 10 mM and 80 mM NAC would be readily uptaken by the plant. These results indicate that the relationship between the behavior of phosphorus release and slag dissolution alters phosphorus availability to the plant.



P use efficiency by plant grown in soil with sewage sludge slag and residues after neutral ammonium citrate (NAC) extraction

GT 07 - 475 - O

HARNESSING PYROLIGNEOUS ACID FOR CIRCULAR AGRICULTURE AND WEED MANAGEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Modern agriculture faces significant environmental challenges as a result of its intensification, driven by the growing global demand for food. One of the main issues is the extensive and uncontrolled use of herbicides for weed control, which may enhance soil degradation. Another present global challenge is the considerable increase in agricultural waste generation. In this context, the pyrolysis of residual biomass emerges as an effective strategy for the management and valorization of such waste. Pyrolysis is a thermal decomposition process of biomass in the absence of oxygen, which produces, among other outputs, biochar, widely recognized for its benefits as a soil amendment, and a liquid fraction rich in organic compounds known as wood vinegar or pyroligneous acid. Although this by-product is still in the early stages of research, some preliminary studies suggest its potential as an organic herbicide for agricultural soils. In this framework, the present study aims to exhaustively characterize pyroligneous acid and assess its phytotoxic effectiveness through germination tests and soil application, with the goal of revalorizing this pyrolysis by-product as a valuable input in sustainable agriculture.

In this case pyrolysis was performed using residual biomass from mixed wood waste at 500 °C in a continuously fed cylindrical reactor at the Euthenia Energy pyrolysis plant (Lucena, Spain). The resulting liquid fraction, corresponding to pyroligneous acid, was analyzed for its physicochemical properties, elemental composition, and content of nutrients and heavy metals. In addition, germination assays and soil tests were conducted to evaluate its potential use as an organic herbicide. Preliminary results indicate that the pyroligneous acid exhibits physicochemical characteristics similar to those of some commercially available herbicides, a high content of organic matter, a rich profile of macronutrients, and an absence of persistent contaminants. Moreover, it has proven effective in inhibiting seed germination without causing adverse effects on soil quality.

These findings support the potential of pyroligneous acid as an effective and environmentally sustainable alternative to conventional herbicides, contributing to both improved waste management and more sustainable agricultural practices.

ACKNOWLEDGEMENTS

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GT 07 - 477 - O

SOIL ORGANIC MATTER QUALITY INFLUENCES EARTHWORM ABUNDANCE IN WOOD PASTURES OF ROMANIA: HIGHER RECALCITRANCE AND LOWER ABUNDANCE UNDER TREE CROWNS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Trees in temperate silvopastoral systems critically shape belowground biodiversity and soil properties; however, their influence remains poorly constrained. To this end, assessing differences in soil organic matter (SOM) content and quality between tree-influenced soils and open pastures is an essential step towards elucidating underlying biogeochemical mechanisms. Here, we examined the relationship between earthworm abundance and SOM content and composition along a gradient of tree influence in 30 oak-based wood pastures in Romania. Based on the expectation that there will be high inputs of oak leaf-litter and bark, we hypothesised that (i) soils near tree trunks would exhibit higher SOM content with greater proportions of recalcitrant compounds such as aromatic and alkyl carbon (C), compared to open pasture soils; (ii) increased presence of such nutrient-poor SOM would consequently decrease earthworm abundance. Sampling was performed at four discrete distances from oak trees of similar age, whereby earthworms and soils sampled at 1 and 3 m were under the tree crown, 7 m was at the edge of the crown, and 24 m was in the open pastureland. Earthworms were collected from the top 25 cm of the soil layer, and the soils were sampled incrementally at three depths down to 60 cm, all on south-facing slopes. Soil organic C (SOC) content was quantified by dry-combustion, while SOC composition was characterised using Fourier-transformed infrared (FTIR) spectroscopy, identifying specific C functional group peaks. We found higher SOC contents in the top soils (0-5 cm) located 1 m distant from tree trunks (64.2 g kg-1), coinciding with greater peak intensities for aromatic C in lignin, phenols, carboxylic acids, and aliphatic C, compared to soils at 24 m in open pastures (44.6 g kg-1). Conversely, polysaccharide-associated peak intensities showed the opposite trend, aligning with the highest earthworm abundance observed at the 24 m distance (208 ind m-2) than at the 1 m distance (128 ind m-2). A stronger positive relationship between SOC contents and aromatic C at 1 m distance ($p < 0.05$, $R2 = 0.82$) relative to 24 m ($p < 0.05$, $R2 = 0.51$) suggested the dominance of recalcitrant SOM near the trees. These findings support our hypothesis that elevated recalcitrant and aromatic SOM content near the tree trunk, which likely decreases the nutritional quality and palatability for earthworms, leads to their decreased abundance despite high SOM concentrations. In temperate silvopastoral systems, we have shown the distinct belowground biogeochemical processes under tree canopies compared to open pasture areas, which suggests differences in SOM stabilisation mechanisms.

KEYWORDS

FTIR, Soil organic carbon, earthworm, C functional groups, aromatic C, oak agroforestry, Transylvania

GT 07 - 481 - O

BIODEGRADATION OF WOOL IN SOIL: TEXTILE CIRCULARITY AND SOIL HEALTH

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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There is growing interest in circular pathways for textiles in the fashion and textile industries, as policy changes encourage designers to embrace concepts of 'sustainable by design'[1]. This is where sustainability is at the core of all stages within a garment or textile life cycle, from design and manufacture, through to consumer use, and finally at end-of-life. Achieving this is challenging considering the variety of textiles and manufacturing processes, the volume of clothing produced and the subsequent textile waste generated at end-of-life.

Alternative more circular end-of-life options that avoid landfill are being explored, and for textiles derived from natural fibres, like wool or cotton, this exploits their ability to biodegrade, such as composting, as a soil amendment product, or through use as geotextile components to mitigate soil erosion. With growing concern over the prevalence of natural microfibres in the environment [2], the environmental impact of biodegradation of natural textiles needs to be fully tested. The intense processing of fibres during textile manufacture and the diverse range of textile finishes that are often applied, such as dyes, flame retardants, waterproofing agents etc mean that biodegradation may be altered and legacy impacts are unknown.

The UNUSUWUL project (https://www.unusuwul.co.uk) seeks to support a sustainable supply chain for UK native wool textiles, from the farm to the brand and help an industry where there is little to no value for wool, which is often buried or burned on farms. As part of the wider UNUSUWUL project, we set up a soil burial experiment to compare the rate of biodegradation and subsequent changes to soil properties, following 3-month soil burial of a range of wool types. The different wool types compared sheep breed and wool characteristics, as well as broader comparisons between natural vs synthetic wool and dyed vs undyed wool. Different wool types (replicated 5 x 5 cm knitted wool squares) were buried at 10 cm soil depth in a 'real world' garden experiment. Here we present our preliminary findings on the biodegradation of the wool types, assessing changes in wool characteristics and impact of biodegradation on soil properties. This data will inform the debate on end-of-life of natural textiles like wool and how best we manage textile waste in a way that also supports soil health and sustainable land management.

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GT 07 - 511 - O

MICROPLASTICS FROM ORGANIC MATTER-RICH SEWAGE SLUDGE: THEIR ROLE IN HEAVY METAL TRANSPORT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Sewage sludge and its derived soil improvers are increasingly applied in agriculture for their valuable fertilising properties, including essential nutrients such as phosphorus, nitrogen, and organic matter. While Lithuanian regulations (LAND 20-2005) and EU directives restrict heavy metals and polycyclic aromatic hydrocarbons in sludge, they overlook microplastics—an emerging class of contaminants. As many countries, including Lithuania, utilise composted or pasteurised sludge in agriculture, microplastics inevitably enter into the soil.

This study aimed to optimise the extraction of microplastics from sewage sludge and assess their morphological characteristics—shape, colour, and size—as well as their potential to adsorb and transport heavy metals. Microplastics were isolated using Fenton's organic matter oxidation reaction, followed by density separation, and then visually identified under a NIKON Z100 stereomicroscope. Separated particles were categorised by colour (e.g., white, transparent, blue, black) and shape (fiber, fragment, sheet, film, sphere). Their sizes were measured using NIS-Elements D software and grouped into 26 classes ranging from 30 µm to 5 mm.

To evaluate the potential of microplastics as carriers of heavy metals (Cd, Cr, Cu, Ni, Pb, and Zn) the extracted microplastic particles were digested in concentrated HCl and HNO_3 (1:5) and analysed using ICP-OES. The results highlight the dual function of sewage sludge—not only as a source of nutrients for agriculture but also as a pathway for microplastic-associated contaminants, emphasising the need for regulatory updates and improved sludge treatment and application strategies.

ACKNOWLEDGEMENTS

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GT 07 - 521 - O

COMPOSTED SEWAGE SLUDGE AS PHOSPHORUS FERTILIZER IN WHEAT GROWN IN REPRESENTATIVE SOILS OF SPAIN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Humans generate an increasing amount of waste. One of these residues is sewage sludge (SS), which contains essential nutrients including phosphorus (P) and that could cover the total demand for phosphate fertiliser in Spain if it was applied to the soil as a fertilizer. When stabilized through composting, the resulting compost (composted sewage sludge, CSW) can be used as an alternative source of P and organic matter in agriculture, reducing the dependence on P derived from finite phosphate rock reserves and promoting a circular economy. This study evaluated the capacity of CSW to supply P to wheat (Triticum durum) in calcareous and non-calcareous soils, with different P phytoavailability, in comparison with a synthetic fertilizer, diammonium phosphate (DAP), and a control without P input under controlled conditions. The physicochemical and respirometric characterization of CSW at the end of the composting process (69 days) indicated that it met the quality requirements for agricultural use according to Spanish legislation (RD 999/2017) except for a slightly low organic matter content. P content in CSW was 46% higher than in the initial value in SS (16.4 g kg-1, dry basis). In the pot experiments, both CSW and DAP, applied at 50 mg P kg-1 soil, significantly increased total P content in soil after harvest (>11%) and in wheat grain (>19%) compared to the control treatment without P application, with no significant differences between the two P treatments. However, P accumulation in straw was significantly higher with DAP in the non-calcareous soil, while the percentage of P allocated to grain was higher in CSW-treated plants, especially in the non-calcareous soil, suggesting a higher P use efficiency with CSW. In the non-calcareous soil, there were no differences in grain weight or harvest index among treatments. In contrast, in the calcareous soil, the one-grain weight was significantly higher with DAP and CSW compared to the control. Additionally, the harvest index was significantly higher in plants grown in the calcareous soil treated with CSW in comparison with the control, with no significant differences observed between CSW and DAP. These results highlight that CSW is a viable source of P for crops grown in Mediterranean soils, including calcareous soils, and its use allows the valorisation of sewage sludge, improve waste management, and the provision of additional nutrients and organic matter to the soil.

ACKNOWLEDGEMENTS

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GT 07 - 524 - O

OPTIMIZING NITROGEN FIXATION OF LEGUME PLANTS AND IMPROVING THEIR USEFULNESS IN ORGANIC FARMING ECOSYSTEMS USING MICROORGANISMS AND BIOSTIMULANTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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This research aimed to investigate the possibility of optimizing nitrogen fixation in legume plants and improving their usefulness in organic farming ecosystems using microorganisms and biostimulants. During the research, beneficial, naturally occurring nitrogen-fixing endophytic and epiphytic microorganisms, as well as selected organic biostimulants and nodule-forming bacterial strains capable of effectively improving nitrogen fixation in traditional (field pea, fababean) and non-traditional (lentil, soybean, chickpea) legume plants, were isolated, cultivated, selected and studied. The effect of individual microorganisms and their mixtures with other biostimulants was evaluated during field experiments in 2017 – 2025 and tested on different legume plants. The amount of nitrogen compounds in different parts of legumes were determined, and the origin and quality of nitrogen compounds in legume seeds and residues were assessed using chemical methods, stable N isotope methods and nitrogen compound degradation modeling experiments. The research was implemented in cooperation with the Lithuanian Research Center for Agriculture and Forestry (LAMMC), Center for Physical Sciences and Technology (FTMC), UAB Bioenergy LT company and Aarhus University (AU).

In this study, a total of 51 endophytic and 82 epiphytic morphologically distinct bacteria were isolated from the roots, stems and leaves of legume plants. The microorganisms that were isolated and showed the highest N fixation efficiency were: Paenibacillus polymyxa, Priestia megaterium, Arthrobacter pascens, Serratia inhibens, Bacillus velezensis, Stutzerimonas perfectomarina, Serratia plymuthica, Pseudomonas oryzihabitans, Priestia aryabhattai.

Commercially available microbial biostimulants with Bradyrhizobium japonicum, Methylobacterium symbioticum, Azospirillum brasilense bacteria were used and selected. N fixation significantly differed depending on legume species. the N fixation capacity of the studied plants was distributed as follows: soybean > field pea > faba bean > lentil > chickpea.

Different plants, due to their specific chemical composition, were characterized by different mineralization (degradation) rates. In our case, soybeans had the lowest C/N ratio – 13.21, which suggests that this crop is the one that decomposes most easily in the soil under the influence of microbiological or physical processes. Similar durability was observed for faba beans, chickpeas and peas, with C/N values of 37.47, 37.07 and 36.32, respectively. Soybean plants were characterized by the lowest content of lignin and cellulose, which allows this plant biomass to participate more easily in the mineralization process. In the case of soybeans, almost 2.6 times more nitrogen was introduced into the soil compared to faba beans and about 1.4 times more comparing to lentils.

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GT 07 - 543 - O

CROP YIELDS OF 16-YEAR PHOSPHORUS CONSERVATION MANAGEMENT PRACTICES INTEGRATED WITH CLOSED-LOOP FIELD WATER RECYCLING UNDER A CORN-SOYBEAN ROTATION IN LAKE ERIE BASIN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Phosphorus (P) loss from agricultural land has been identified as one of the predominant causes of harmful algal bloom recurrence in Lake Erie. Three innovative conservation management practices, including P-based manure application, soil legacy P drawdown (i.e. no additional P application), and closed-loop farm field water recycling (i.e., controlled drainage with sub-irrigation system, CDS), have shown to be able to reduce runoff P losses from agricultural lands (1,2,3). However, their impacts on crops must be clarified using long-term field studies for production sustainability, particularly when multiple management practices are integrated. Our study aimed to quantify the long-term integrated effects of these three innovative practices on crop yields and N and P uptake and removal, in comparison with current regular practices. We conducted a 16-year field experiment from 2008 to 2023 in a clay loam soil with a corn (Zea mays L.)-soybean [Glycine max (L.) Merr.] rotation. In terms of crop yields and nutrient uptake and removal, the interaction between CDS and soil P management was insignificant. Compared with inorganic fertilizer, solid cattle manure application to meet crop P requirement produced similar corn and soybean yields over 16 years; liquid cattle manure application tended to cause lower corn yields, presumably due to low N use efficiency, which, however, did not occur to soybean. Both soil legacy P drawdown and CDS consistently produced similar corn and soybean yields and nutrient uptake and removal, compared with continuous P additions and regular free drainage, respectively. Our results help to develop best management practices to reduce P losses without compromising crop yields.

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GT 07 - 569 - O

USE OF OIL PALM DECANTER CAKE AS SOIL AMENDMENT AND INORGANIC FERTILISER SUBSTITUTE FOR GROWING OIL PALM SEEDLINGS IN THE NURSERY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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The escalation of palm oil mill (POM) waste production, such as oil palm decanter cake (OPDC), requires a more sustainable waste management approach [1]. Therefore, this research aims to investigate the potential of using OPDC as a soil amendment and fertiliser substitute in oil palm (OP) nurseries. The physicochemical properties of OPDC from Merotai Oil Mill, Sabah, Malaysia was evaluated based on different sampling areas namely OPDC exit silo, open area dumping platform and, under the closed system roof facility [2]. The result suggested that OPDC can be used directly as an organic amendment regardless of its decomposition stages due to its reasonably stable pH (>4.5), low C-N ratio (<25), and high organic carbon (>50%) and total nitrogen (>2.5% dry mass). From these results, a nursery trial was set up to determine the effect of OPDC application on soil chemical properties and the OP seedling growth response. Eight treatments were evaluated using different OPDC and topsoil mixture ratios and multiple levels of nutrient input. OPDC application as soil amendment at a 50% mixture ratio significantly improved the soil's chemical properties, namely pH, conductivity, organic carbon, and total nitrogen up to 6.65, 420.75 pS/cm, 2.34%, and 0.32%, respectively (P<0.05). OP seedlings could withstand OPDC application up to a 50% mixture ratio with topsoil from transplanting up to twelve months old in biological age [3]. Seedlings with up to 50% OPDC in the planting media (T5–T8) showed comparable growth to controls, even without fertiliser, across six, nine, and twelve months (P>0.05). Although with a full fertiliser regime (T2, T3, and T4), OPDC application on OP seedlings has neither caused leaf phytotoxicity nor deficiency after a twelve-month growing period (P>0.05). Treatments with fertiliser reduction showed no significant (P>0.05) leaf nutrient deprivation due to replenishment by OPDC at a 50% mixture ratio [4]. A minimum 50% ratio of OPDC added to the topsoil used (T5, T6, T7 and T8) has suggested a possible discount of inorganic fertiliser application from 25%, 50%, and even up to 100% rate reduction with comparable growth performance. In conclusion, the use of OPDC as a soil amendment and fertiliser substitute has shown promising results for oil palm nursery applications.

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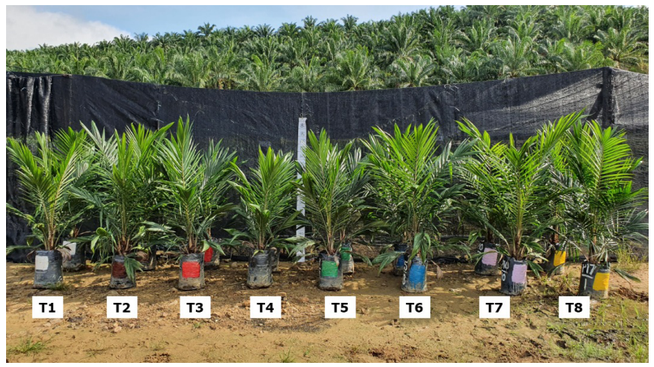
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GT 07 - 589 - O

BALANCING NUTRIENTS IN LIVESTOCK-DERIVED FERTILIZERS TO REDUCE NUTRIENT LOSSES FROM AGRICULTURAL SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The application of livestock-derived products to agricultural soils offers notable agronomic and environmental benefits, particularly by increasing soil organic carbon (SOC) and reducing reliance on synthetic mineral fertilizers. However, these organic materials often present nutrient imbalances that misalign with crop requirements, resulting in nutrient surplus and high risks of nitrogen (N) and phosphorus (P) losses to both water bodies and the atmosphere. Such losses, via nitrate leaching, ammonia (NH3) volatilization, nitrous oxide (N2O) emissions and P runoff, pose significant sustainability challenges. This research aims to reduce nutrient losses from agricultural soils by improving the nutrient balance in livestock-derived fertilizers, thereby enhancing the synchronization between nutrient supply and crop demand.

In regions with intensive livestock farming, cattle manure is frequently utilized for biogas production through anaerobic digestion. The resulting digestate is typically mechanically separated into a N-rich liquid fraction and a P-rich solid fraction, leading to a significant nutrient imbalance with respect to the crop requirements when these fractions are applied to soil. In this study, we tested the effectiveness of cattle manure pre-treating using hydrodynamic cavitation combined with enzymatic hydrolysis (employing phytase and a blend of cellulase, hemicellulase, and pectinase), prior to anaerobic digestion. This approach aimed to enhance biogas yield while promoting P solubilization and its transfer from the solid to the liquid fraction. This allowed to efficiently recover ammonium and phosphate from the digestate liquid fraction as struvite, a slow-release fertilizer. Concurrently, the pre-treatment contributed to shifting the N:P ratio of the solid fraction from 6.4 to 9.6, better aligning with the crop nutrient demand.

To evaluate the performance of the developed products in reducing nutrient losses from soils, a greenhouse experiment was then conducted using two soil types cultivated with Lolium multiflorum Lam. Treatments compared the application of conventional mineral fertilization to the substitution of part or all of the mineral fertilizers with the digestate solid fraction obtained with and without pre-treatment and the recovered struvite. All treatments were adjusted to apply the equivalent of 120 kg N/ha and an N:P molar ratio of 9.5. Emissions of N2O and NH_3 are being measured. Results showed that the nutrient-balanced solid digestate could fully replace both mineral N and P fertilizers, while struvite application reduced mineral N input by up to 10% and completely replaced mineral P. This approach can therefore have strong potential to mitigate NH_3 and GHG emissions from agricultural soils, while also preventing P overapplication.

ACKNOWLEDGEMENTS

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GT 07 - 654 - O

THE EFFICACY OF PLANT BIOSTIMULANTS ON SNACK CARROTS YIELD, QUALITY, AND SOIL MICROBIAL ACTIVITIES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Plant biostimulants (PBs) are recognized within the European Union as fertilizing products that enhance plant nutrition by improving nutrient availability and Nutrient Use Efficiency (NUE), independent of their nutrient content (Regulation (EU) 2019/1009, 2019). A recent meta-analysis highlighted that PBs can increase various crop yields by an average of 17.9% under field conditions, with more pronounced effects observed in vegetable crops and under lower soil fertility (Li et al., 2022). However, their efficacy is influenced by climate, soil type, and application method, and comprehensive field trial data is limited.

We evaluated the efficacy of 10 commercially available biostimulants, derived from diverse microbial and non-microbial sources on organically grown snack carrots. Field experiments were conducted at Aarhus University (AU) research stations in Denmark: at AU-Årslev in 2021 on sandy loam soil, and at AU-Auning in 2022 on sandy soil. Standard agronomic practices were applied to both biostimulant-treated and control (no biostimulant) plots. Biostimulants were applied according to the distributors' instructions. We measured several plant parameters, including total and marketable yield, size distribution, dry matter, and sugar content. Additionally, soil microbial enzyme activities, nutrient availability, and nutrient use efficiency indices were determined at both locations.

Results indicated that PBs significantly increased total yield by 0.66-2.24 tons ha-1 ($p<0.1$) in the sandy loam soil in 2021. In contrast, effects on total yield in sandy soil in 2022 varied from -2.21 to +5.14 tons ha-1 ($p<0.05$), showing that PB applications can also have negative impacts depending on soil or local growth conditions. PBs significantly affected snack carrot size distribution ($p<0.05$), promoting smaller sizes in sandy loam and larger sizes in sandy soil, and also variably influenced sugar content, highlighting their importance in nutritional quality. Despite these positive effects on yield and quality-related parameters, no significant effects ($p>0.05$) were recorded on soil nutrient availability or microbial activities at either location.

In conclusion, selected PBs show potential for improving the yield and quality of organically grown snack carrots. However, their efficacy is highly dependent on local soil conditions and can sometimes be negative. Further research is essential to comprehensively evaluate the long-term efficacy of PBs across a wider range of soil and management conditions.

ACKNOWLEDGEMENTS

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Regulation (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products http://data.europa.eu/eli/reg/2019/1009/oj

GT 07 - 674 - O

A HOLISTIC APPROACH TO RECOVERY AND REUSE OF TREATED WASTEWATER AND ITS BY-PRODUCTS IN A CIRCULAR ECONOMY PERSPECTIVE: INSIGHTS FROM THE WIDER UPTAKE H2020 PROJECT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Rapid global population growth is pressing the agricultural sector for a significant increase in food production. This has intensified reliance on irrigation and fertilizers to improve crop yields. However, water scarcity and freshwater degradation are critical challenges, particularly in arid and semi-arid regions [1]. Moreover, chemical fertilizers enhance crop productivity, but their excessive use raises concerns about long-term sustainability and soil health [2]. A promising alternative is the recovery and reuse of nutrients from wastewater. Treated wastewater (TWW) from secondary treatment plants contains essential nutrients like nitrogen and phosphorus, with concentrations reaching 30 mg NH_4^+ L^{-1} and 10 mg PO_4^{3-} L^{-1} [3].

To support the transition from linear to circular economy, wastewater treatment plants are expected to evolve into Water Resource Recovery Facilities (WRRFs), capable of recovering treated wastewater, nutrients, and organic matter for agricultural reuse. Indeed, the H2020 project WIDER UPTAKE was launched to address regulatory, technical, and social barriers for implementing circular water-smart solutions. Within this framework, a pilot WRRF and a greenhouse were installed at the University of Palermo (Italy) to test and validate integrated recovery strategies [4]. The research followed a stepwise approach, from batch to pilot and real scale. Batch tests were performed to evaluate nutrient adsorption using low-cost, regenerative materials, such as zeolite for NH_4^+ and biochar for PO_4^{3-}, respectively [4]. These were then validated in pilot-scale column experiments using TWW. In a final phase, nutrient-enriched materials and TWW were tried in pot trials to assess effects on soil quality and plant growth [5]. Additionally, zeolite and biochar were tested as bulking agents in composting sewage sludge, enhancing compost maturity and nutrient value.

The results highlighted a paradigm shift towards a wastewater treatment oriented to contaminant removal and resource recovery, integrating treated wastewater in agricultural practices as an essential approach. This transition, embracing principles of circular economy and environmental sustainability, requires technological innovations, changes in policies and regulations, and a collective commitment to a more sustainable future.

This study provides a roadmap for resource recovery, demonstrating that combining TWW reuse, adsorption technologies, and composting can encourage sustainable agriculture and the transition to a circular economy.

ACKNOWLEDGEMENTS

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GT 07 - 677 - O

VISUALISING THE AMELIORATION OF SUBSURFACE SOIL ACIDITY WITH X-RAY TOMOGRAPHY: THE EFFECT OF NOVEL MICRONISED LIME WITH POLYMERS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 02. SOIL PHYSICAL CHEMISTRY

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Agricultural lime is commonly used to ameliorate acidic soils, however, surface application tends to be ineffective at addressing subsurface acidity (depth ≥ 30 cm) due to limited solubility and mobility of lime [1]. To ameliorate subsurface acidity and the associated constraints to plant productivity, lime can be applied into subsurface layers, but it is expensive and not applicable to no-till farming systems [2]. To address subsurface acidity and the restricted mobility of lime applied on soil surface, a range of novel liquid liming products based on micronised lime, and pyrogenic carbon in combination with water-miscible emulsifying polymers were engineered. The role of these new products was evaluated by assessing changes to soil pH, plant growth and temporal movement down the soil profile (0 - 40 cm), using plant bioassays, Micro-Computed Tomography (MCT) and wet chemistry techniques including aluminium speciation. Preliminary results indicate that surface application of 2.2 t/ha of either superfine agricultural lime or novel liming products increased topsoil pH from 4.6 to 6.8 after 14 days, but only the novel products increased subsurface pH above pH ≥ 5.5. This coincided with an increase in plant shoot biomass of 26-40 % compared to agriculture lime and the nil amendment control. This paper will present MCT images of changes to plant root structure following amelioration of subsurface acidity. The ability to ameliorate subsurface acidity with surface application of these novel products will potentially provide a step-change in management options for farmers, resulting in productivity gains and long-term soil improvement.

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GT 07 - 710 - O

TOWARDS THE BEST PRACTICE IN USING SOFTWOOD BIOCHARS ON BOREAL SOILS: RESULTS FROM TWO EXPERIMENTS THROUGH 15 YEARS ON SOILS, NUTRIENT CYCLING AND CROPS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Biochars have notable potential in sequestering atmospheric carbon over long terms and offer various agricultural and environmental co-benefits. However, there is limited information about the long-term effects of added biochars, as there are only handful of continuously monitored biochar field experiments expanding over a decade, and especially poorly have been studied the long-term effects from boreal regions. The soils in northern colder boreal regions typically have higher carbon content and undergo continuous freeze-thaw cycles. Therefore, effects of biochars in these regions may differ from those observed in warmer climates.

We studied the effects of a single application of softwood biochars on two contrasting boreal agricultural soils (fertile, fine-textured Stagnosol [1] and a nutrient-poor, coarse textured Umbrisol [2]), both with high initial soil organic carbon contents, over 13 years following the application in 2010 or 2011. Further, in 2023, we applied nitric acid activated and subsequently nutrient-enhanced biochars to some of the plots to establish the best practice of biochars in the Nordics. We focused on plant yield formation as well as nutrient uptake dynamics of all major Finnish field crops, as well as on soil physical properties and greenhouse gas emissions.

We found that the ability of biochar to enhance the supply of nutrients to plants and hence to improve the crop biomass yield exists in boreal conditions, although these effects were minimal and not consistent over the years. Biochars notably increased plant K content, and reduced the plant content and uptake of Al and Na in several years in Stagnosol. The relative plant contents of Cd and Ni in Umbrisol, and P, K, Mg, S, Al, Cu, Fe and Ni in Stagnosol increased over the years [3]. Despite these increased plant contents, the yield improvements over the control were sporadic.

The enhanced plant available water and reduced bulk density previously reported during the initial years were faded in long-term, likely due to dilution of biochar concentration in topsoil. However, the potential of biochar to affect N2O emission persisted, even seven years after the application, this contributed to reduced yield-normalized non-CO2 GHG emissions.

The preliminary data from the latest growing seasons 2023-2025 provides first insights on the effects of nutrient-enhanced biochars in field conditions and suggests that such biochars can support the yield formation of crops especially during the early-season drought.

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We acknowledge all the AgriChar research group members over the years who have contributed into keeping these globally unique field experiments running and in active monitoring since 2010. We could not have done this without you!

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GT 07 - 732 - O

ARE BIODEGRADABLE PLASTICS SAFE FOR SOIL APPLICATIONS?

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Biodegradable plastics present a promising approach to mitigating plastic and microplastic pollution in soils. Although their production remains relatively costly, their use in agriculture is projected to expand, underscoring the need to assess their effects on both productive and non-productive soil functions. Our recent research has focused on poly-3-hydroxybutyrate (P3HB), a naturally occurring bacterial polyester used for carbon and energy storage. We investigated its degradation in soil and its impacts on soil health and plant development, under concentrations spanning low to high contamination levels akin to mulching or plastic litter.

The results demonstrated that elevated concentrations of P3HB adversely affected plant growth and their nutritional characteristics [1] primarily by disrupting soil nutrient balance [2], and by modifying the soil microbial community [3]. Attempts to mitigate these effects using compost [4] or plant growth-promoting bacteria [3] failed, while the application of digestate provided limited support for plant performance [4]. The intense microbial activity triggered by P3HB degradation increased enzyme production and induced a positive priming effect, accelerating the turnover of native soil organic matter [5]. Interestingly, the extend of carbon use by microorganisms was very high and increased with increasing P3HB concentrations, likely due to nutrient limitations, oxygen depletion, accelerated soil desiccation and other factors [6]. Indeed, soil texture appeared an important factor as the fast biodegradation caused oxygen depletion, which turn soil aerobic processes into anaerobic [7].

Despite these drawbacks, P3HB may offer specific benefits in targeted applications. As a readily degradable substrate, it has the potential to temporarily supplement soil organic matter [2] and stimulate microbial activity, particularly in degraded soils. The insights from this study can inform the optimized use of P3HB in agriculture or soil remediation, aiming to balance its risks with potential benefits.

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GT 07 - 764 - O

REGIONAL SPECIFIC MEASURES TO REDUCE TRADE-OFFS AND PROMOTE SYNERGIES BETWEEN CLIMATE CHANGE MITIGATION AND SOIL HEALTH.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The EU mission “Soil deal for Europe” was established to promote the protection and restoration of European soils, and to ensure sustainable soil management. It aims, amongst others, to reduce chemical inputs and soil pollution. At the same time, the EU has set targets to achieve climate neutrality in 2050, and soils play an important role in this by sequestering CO2 from the atmosphere. However, increased carbon sequestration may lead to increases in other greenhouse gas emissions, such as nitrous oxide (N2O). Measures to reduce emissions could counteract the reduction of environmental pollution in agricultural soils. For instance, cover crops are a widely proposed measure as they can decrease the need for synthetic fertilizer by supplying N to the following crop, and they can increase the C input to the soil. The reduction of synthetic fertilizer reduces the chemical inputs and production emissions. However, the additional N in the soil might lead to an increase in N2O emissions and NO3 leaching. Whether the synergies or trade-offs prevail will ultimately depend on the local circumstances, however, this is at the moment often not taken into account when proposing measures on a European scale.

In this study, we collected and analyzed commitments of European farmers to take measures to reduce the greenhouse gas emissions of their soils and thus contribute to climate neutrality. An inventory of mitigation measures was built and used to develop scenarios for Europe, to assess the contribution towards the goal of climate neutrality, and how the measures affect soil nutrient flows. We focused on measures farmers take to reduce N2O emissions of soils to lower their climate impact. The effect of measures was modelled by the Miterra-Europe model at NUTS2 level in order to detect regional differences and to be able to identify synergies and tradeoffs between the N2O measures, carbon sequestration, and environmental pollution through soil nutrient flows. Miterra-Europe is a dynamic model which is able to calculate greenhouse gas emissions (CO2, CH4, and N2O), nitrogen emissions and nutrient losses to ground -and surface water (including N, P, K, S, Mg, Ca, Cu, and Zn) and soil organic carbon stock changes.

Amongst the most frequently proposed soil related N2O mitigation measures were precision fertilization, adding legumes to the crop rotation, cover crops, and applying low emission fertilization. We expect that the effect of measures on climate neutrality and soil nutrients flows will vary regionally. Therefore, we stress that especially when addressing multiple environmental challenges, a regional specific approach is needed as applied in this study.

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GT 07 - 767 - O

A CONTRIBUTION TO MISSION SOIL FROM TWO HORIZON PROJECTS: SIMBA AND DELISOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Enhancing soil health is fundamental to advancing sustainable agriculture and reducing dependence on synthetic inputs. The transition toward sustainable agriculture requires innovative strategies that enhance crop productivity while preserving soil health and reducing environmental impact. Field-based investigations evaluated the efficacy of biochar (produced from wood or different agro-food residues) alone or combined with plant growth-promoting microbes (PGPMs) in maize, wheat, and tomato cultivation systems [1,2,3,4]. Over multiple growing seasons, co-application of these biofertilizers demonstrated consistent improvements in plant physiology—such as increased chlorophyll content, grain yield, and fruit quality. Untargeted metabolomic profiling revealed treatment-driven modulation of key metabolic pathways, including the upregulation of beneficial lipids and flavonoids, and enhanced accumulation of health-promoting compounds in edible plant tissues. In wheat, improved viscoelasticity of dough was observed through altered gluten subunit composition, particularly under drier climatic conditions. Tomato trials showed significant reductions in unripe fruit percentage and increased commercial value, alongside a notable reduction in chemical fertilizer input and greenhouse gas emissions. Rhizospheric analyses revealed that microbial community richness and diversity remained stable, indicating that these amendments do not disrupt native microbial ecology. The benefits were consistent across climatic conditions and crop types, underscoring the robustness and scalability of this approach. Altogether, the data highlight the potential of biochar–PGPM combinations to regenerate soil ecosystems and support resilient, low-impact agricultural systems.

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In the network of Mission Soil, the “Interuniversity National Consortium for Environmental Sciences” (CINSA) has participated and is participating to two EU projects: SIMBA (Sustainable Innovation of Microbiome Applications in Food System) and DeliSoil (Delivering safe, sustainable, tailored and societally accepted soil improvers from circular food production processes for boosting soil health), for which the authors acknowledge for financial support. A third project MULTISOIL will start in October’25. The abstract presented summarizes the results obtained in SIMBA and DeliSoil.

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GT 07 - 792 - O

FROM INVASIVE PLANT TO FERTILIZER: INDUSTRIAL-SCALE COMPOSTING OF WATER HYACINTH WASTE FOR SOIL IMPROVEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Water hyacinth (WH) [Eichhornia crassipes (Mart.) Solms] is one of the 41 invasive alien species of concern to the European Union (Regulation (EU) 1143/2014; European Union, 2014). It blankets waterways, harms ecosystems, and hinders navigation. However, its biomass contains high levels of nutrients that should be returned to the soil. This study aimed to evaluate the industrial composting process of WH waste blended with forestry residues and horse manure. As part of the BioComp_3.0 project, two industrial composting piles were assembled: (i) pile A, composed of 40% WH, 40% forestry residues, and 20% horse manure (V = 286 m3); and (ii) pile B, consisting of 50% WH waste and 50% forestry residues (V=192 m3). Each pile was aerated by turning three times during the process, and compost maturation was completed after 8 months. Both piles reached high temperatures (above 55 °C) for extended periods – ideal conditions for microbial activity and for eliminating seeds and propagules. After composting, the C/N ratio decreased from 30 to 17 in pile A and from 31 to 16 in pile B – values characteristic of humus. The final composts exhibit high organic matter content: 44.6% for pile B and 42.3% for pile A. Nitrogen content is 1.3% in both. The pH and electrical conductivity values are 8.4 and 1.65 mS/cm for pile A, and 8.3 and 1.57 mS/cm for pile B, respectively. The concentrations of metals (Cu, Zn, Pb, Cr, Ni, and Hg) are similar between the piles:

- Pile A: 37 mg/kg (Cu), 115 mg/kg (Zn), <23.45 mg/kg (Pb), 39 mg/kg (Cr), 32 mg/kg (Ni), and 0.045 mg/kg (Hg)
- Pile B: 34 mg/kg (Cu), 131 mg/kg (Zn), <23.45 mg/kg (Pb), 41 mg/kg (Cr), 28 mg/kg (Ni), and 0.036 mg/kg (Hg)

These results indicate that both farming composts contain low levels of heavy metals, meeting the limits set by Portuguese regulations (Portaria nº 185/2022, July 21) to be classified as “Class I” fertilizer materials and suited to be applied in Organic Farming. Currently, these new farming composts are being benchmarked against commercial fertilizers through greenhouse and open-field experimental trials on the lettuce crop.

This approach supports a closed-loop system by converting a problematic weed into a valuable agricultural resource. It benefits the environment and delivers economic and social advantages, contributing to the circular economy.

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ECONOMIA E MAR, AMBIENTE E AÇÃO CLIMÁTICA E AGRICULTURA E ALIMENTAÇÃO, 2022. Portaria n.º 185/2022 de 21 de j



GT 07 - 809 - O

MULTIFUNCTIONAL ROLE OF MICROBIAL BIOLOGICALS IN SOIL RESTORATION AND SUSTAINABLE CROP PRODUCTION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Soil degradation, resulting into organic matter loss severely impairs soil fertility, structure, and resilience, threatening sustainable agricultural productivity. This study investigates the impact of integrated biological approaches on soil labile carbon sequestration, microbial biodiversity, enzymatic activity, and maize yield within a long-term stationary field experiment on low-humus chernozem soils under continuous maize cultivation. Application of microbial-based biological products, including microbial decomposers and bioagents, significantly increased labile carbon content by 0.11–0.18% compared to untreated controls, supported by enhanced organic matter transformation coefficients indicative of predominant synthesis over mineralization processes. Monitoring of soil fungal populations demonstrated increased abundance of beneficial Trichoderma fungi, reflecting improved soil ecological functionality. Functional biodiversity, assessed via BIOTREX Community-Level Physiological Profiling, was significantly elevated, with diversity indices rising from 3.66 in controls to 4.87–5.61 in treated variants due to enhanced soil biological activity. These biological interventions accelerated crop residue decomposition, creating favorable conditions for nutrient cycling and carbon stabilization. Correspondingly, maize grain yields increased substantially, demonstrating agronomic benefits of improved soil health management.

The war in Ukraine has resulted in extensive soil degradation due to explosions, heavy metal contamination, and hydrocarbon pollution. BTU has developed a comprehensive bioremediation strategy to restore these damaged soils. Studies conducted on war-affected soils show that after 90 days after applying biologicals with detoxifying properties, microbial communities in contaminated areas began to recover, approaching natural soil conditions. Additionally, plant biomass in treated areas increased by 7–10%, and when combined with mineral amendments, growth gains exceeded 24%. This demonstrates the potential of biologicals in remediating war-damaged soils and restoring agricultural productivity.

The results highlight the diverse role of biological soil products in restoring degraded soils by stimulating microbial diversity, improving biochemical soil functions, and supporting sustainable crop production. Such integrative biological strategies represent a promising component of resilient agricultural systems aimed at mitigating soil degradation and promoting long-term soil fertility and ecosystem services.

GT 07 - 823 - O

HUMIC SUBSTANCES FOR AMELIORATING AL TOXICITY OF BARLEY GENOTYPES IN AN ANDISOL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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In Los Lagos Region of Chile, acidity is a typical feature of most cultivated soils. In such soils, aluminum (Al^{3+}) is present at high levels, which can lead to toxic symptoms and decreased productivity in plants, particularly in those more sensitive, such as barley (Hordeum vulgare L.). Strategies to ameliorate negative effect of Al include the identification of genotypes more resistant to Al3+, application of CaCO3 (lime commonly used to raise soil pH), and the addition of organic amendments, more recently humic substances (HS). These materials are able to react with Al3+, forming soluble or adsorbed Al complexes, and potentially reducing its availability. There are few studies evaluating the effect of the application of these molecules on Al toxicity in volcanic soils. The main objective of this work was to evaluate the effect of application of HS on some properties of a volcanic soil (Typic Hapludands, pH=5.20, exchangeable Al3+ =0.61 cmol(+)/kg, silty loam) and the response of barley plants with different Al3+ sensitivity.

A 2-stage methodology was performed: i) a short-term nutrient culture (8 days, cycles with or without 100 mM Al3+) (1) was used to select 2 genotypes (from 32) with contrasting sensitivity to Al3+, and ii) a pot experiment was conducted by using those 2 barley genotypes. The pot experiment (1.5 L) considered as treatments: i) control (no amendments) HS ii) application of HS (30 kg/ha), iii) application of HS (300 kg/ha), iv) application of CaCO3 (2 ton/ha), and v) combined application of HS+CaCO3 (30 kg/ha + 1 ton/ha, respectively). Three plantlets of barley plants were grown in each pot (filled with soil at field bulk density) for 35 days in shadow conditions (30% interception). All treatments received a N fertilization (50 kg/ha) as urea. Experimental design was a complete randomized with 4 replications. During the experiment growth parameters were followed, and the end roots and aerial dry matter (DM) production were determined, and soil properties were analyzed. From the initial experiment, 75% of the lines were classified as highly to moderately sensitive to Al3+ stress. In the pot experiment, the lime addition caused the greatest impact in increasing the pH and reducing the exchangeable Al3+ in the soil, while the application of HS (10x) decreased ($p<0.05$) the exchangeable Al3+ in one plant genotype. The greatest benefit using the amendments was noted for the highly tolerant Al3+ line, in which growth parameters and DM showed more significant differences ($p<0.05$) over the control. In both lines, all amended treatments showed significantly higher total DM production over the control, while the plants receiving the higher rate of SH displayed similar response to the CaCO3 treatment. The effect of SH may be mediated by both the HS stimulatory effect on the plants and the reduction of available Al (coupled to the raise of soil pH or by complexation by HS).

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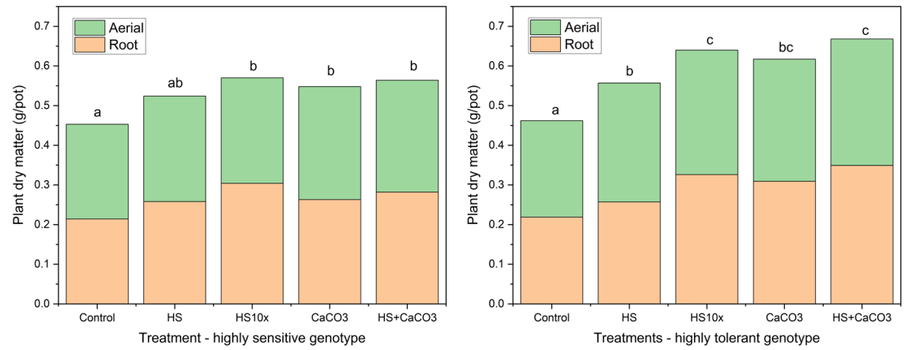


Figure 1. Effect of the treatments on dry matter productos of barley genotypes with different Al3+ sensitivity. For each genotype, different letters indicate singnificant differences for total dry matter (LSD, $p<0.05$)



GT 07 - 1134 - O

HARNESSING SOIL MICROBIOMES FOR SUSTAINABLE CROP RESILIENCE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil health is a cornerstone of resilient agriculture. In a context increasingly affected by climate change, water scarcity, and progressive soil salinization, it is estimated that over 50% of arable land will be under severe abiotic stress by 2050. This alarming scenario calls for innovative and sustainable approaches based on microbiome knowledge and soil functionality recovery.

This presentation highlights how harnessing the Soil Microbiome using functional microbial consortia can optimize crop nutrient efficiency, restore key soil functions, and significantly reduce the impact of water and salinity stress. Field results in both woody and horticultural crops demonstrate improvements in physiological parameters such as photosynthetic activity, root-soil interaction, leaf water status, and expression of genes involved in osmotic stress tolerance.

The approach relies on the use of microbial bioeffectors, selected and fermented through tailored industrial processes to preserve their viability and functionality upon application. Moreover, we introduce the concept of “BIOADAPTA®”, a comprehensive strategy that not only introduces beneficial microbes but also enhances the native soil microbiome by applying microbial signaling metabolites (elicitors) that act synergistically.

Driven by strong R&D investment in agricultural biotechnology, this approach offers a scalable and effective solution for restoring degraded soils and strengthening the resilience of agroecosystems, without compromising productivity. The presentation will explore key case studies and scientific underpinnings supporting this paradigm shift toward soil regeneration.

GT 07 - 225 - F + P

DEMONSTRATING THE AGRONOMIC POTENTIAL OF NITROGEN AND PHOSPHORUS RECOVERY FROM WASTE STREAMS IN THREE EUROPEAN RIVER BASINS (EBRO, LIELUPE, AND DANUBE)

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Nutrient pollution and the rising costs of fertilizers are major challenges to agricultural sustainability and environmental protection. Recovering nitrogen and phosphorus from waste streams emerges as a promising strategy to mitigate environmental impacts while producing alternative fertilizers. Effective implementation requires an integrated political, regulatory, and governance approach. Following this, NENUPHAR aims to develop governance and value chain models for nutrient recovery from manure, sewage sludge, and dairy wastewater. The project focuses on four main innovations: a methodology to estimate N/P emissions from fertilizer use, network governance models to enhance stakeholder cooperation, the design of economic and financial incentives for adoption, and the development of efficient nutrient recovery technologies. Demonstrations are being carried out in three European river basins (Ebro, Lielupe, and Danube) and replicated in Cyprus and Bornholm. The initiative aims to recover 273 tons of nitrogen and 72 tons of phosphorus, treating approximately 38.3 million tons of manure, 252,000 tons of dry sludge, and 4.3 million cubic meters of dairy wastewater.

As part of the NENUPHAR demonstration in the Ebro basin, a lab trial in a growth chamber was established to evaluate the agronomic performance of fertilizers derived from recovered nutrients compared to conventional and untreated controls. The study characterizes various fertilizer types, including the solid and liquid fractions of slurry and digestate, ammonium sulfate from digestate, urea, and phosphate, analyzing total phosphorus, soluble phosphorus, total nitrogen, ammonium nitrogen, nitrate, pH, and electrical conductivity.

The growth chamber program was used to simulate real daily environmental conditions with constant wind speed (75%). Temperature, humidity, and lighting were adjusted across 15 segments, from dawn (Segment 1) to night (Segment 15), with gradual changes to mimic natural transitions. CO_2 was kept constant, as the focus was not on plant growth but on leaching from the applied products in the soil. Two trials will be conducted: one with bare soil and another with plants. Bare soil will be placed in 13 cm x 13 cm x 21 cm (3.5 l) pots, irrigated progressively with demineralized water to preserve structure. Organic fertilizers (slurry, digestate) and ammonium sulfate will be applied based on recommended N limits. In addition, the study will include pots with mineral fertilizers as a control, as well as pots serving as a negative control. This setup aims to evaluate leaching from the chosen soil treatments under realistic conditions.

This trial aims to provide quantitative evidence on the agronomic viability and environmental safety of using recovered fertilizers, supporting the transition to a circular, zero-pollution agricultural model in Europe.

ACKNOWLEDGEMENTS

NENUPHAR project (grant agreement Nº 101082169)



GT 07 - 287 - F + P

LEACHED NITRATE QUANTIFICATION IN MAIZE: MICROPLOT, PLOT AND BASIN LEVEL.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Nitrogen leaching is the movement of surplus fertiliser-derived nitrogen into groundwater, representing a serious threat to water quality in irrigated agriculture [1]. Sustainable fertilisation strategies are essential to reduce nitrogen losses and minimise environmental impact [2]. Although regulations address return flows at the basin level, assessing fertilisation effects at smaller scales—plots and microplots—is crucial to understand these dynamics and extrapolate results.

This study aims to evaluate nitrate concentration and environmental impact at microplot, plot, and basin levels during an irrigated maize crop. Specific objectives include quantifying fertilisation, monitoring maize growth, estimating nitrate leaching, and identifying optimal fertilisation strategies.

The research takes place in the 2,000 ha Reguero basin (Pertusa, Huesca) focused on plots nº16 and 17 of polygon 503 (5.5 ha), where maize is cultivated. Two nitrogen fertilisation strategies are compared: pig slurry and mineral fertilisers, applied at usual and best-practice rates [3].

Given the basin's lack of previous study, it is first delimited, and the plot characterised by identifying crops and fertilisation strategies. Return flows are sampled biweekly, and nitrate concentration and electrical conductivity (EC) are measured. The plot is equipped with a drainage system (depth: 80–1500 cm), collecting leachates into the basin. These drainage flows are also characterised by the same frequency.

Microplots with different fertilisation treatments are arranged in randomized blocks with three replicates, based on five years of crop response data (NDVI). Full-Stop sensors are placed below the maize root zone and sampled weekly for EC and nitrate. Crop monitoring is performed every 2–5 days using satellite imagery (3 m pixel size) to extract NDVI.

Results allow quantification of nitrate concentrations at the three levels. However, estimating flow rates is needed to determine nutrient mass export at each scale.

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GT 07 - 348 - F + P

EVALUATION OF ORGANIC FERTILISERS AS AN ALTERNATIVE TO PHOSPHATE MINERAL FERTILISATION IN A WHEAT-SUNFLOWER ROTATION.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Ensuring agricultural productivity usually requires a large amount phosphorus (P) supply. The European Union (EU) advocates for a sustainable agricultural model with less use of synthetic fertilizers derived from phosphate rock deposits, a finite and unevenly distributed resource on the planet. New bio-based fertilizers (BBFs) from recycled waste could help close the nutrient cycles, serving as an alternative to mineral phosphorus fertilizers based on mine raw materials. To better understand their efficiency and residual effect, bio-based phosphate fertilizers of different nature (i.e., composts, plant and food waste, ashes, precipitates, or animal byproducts) were tested in a field trial during a two-year crop rotation involving winter wheat and sunflower.

Overall, the results obtained with the BBFs were positive compared to the soluble synthetic mineral fertilizer, although differences were observed between the two crops. The soluble mineral fertilizer showed the highest wheat biomass yield at harvest, with a value of 285.5 g, meanwhile MAX (169.9 g) and DIGE (211.0 g) led to the lowest biomass yield. However, no differences were observed in grain production. MOGE showed the highest harvest index. No significant differences were observed in micronutrients concentrations in plant tissues as well as in P uptake by plants. Soil total P after wheat showed significant differences between BBFs, with RSU showing the highest value (26.35 mg kg-1). In the second year with sunflower, fertilizer affected biomass yield, with MAX showing the highest biomass, while MOGE had the lowest biomass yield. Regarding soil health indicators, it was also influenced by BBFs. In this regard, MSW showed the highest alkaline phosphatase activity (430.0 mg PNP kg-1 h), with no differences for acid phosphatase or beta-glucosidase activities.

The results were greatly influenced by the prevailing drought conditions during the trial, which, in the case of sunflower, required replanting and subsequent repetition of the trial. Some tested BBFs were effective alternatives to mineral fertilization, without decreasing crop production and acting as slow-release fertilizers with a significant residual effect.

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KEYWORDS

BBFs, phosphorus, circular economy, efficiency

GT 07 - 355 - F + P

USE OF BIOSORBENTS FROM WASTE RECYCLING AND MYCODEGRADATION FOR THE EFFECTIVE AND LOW-COST ELIMINATION OF ORGANIC SOIL POLLUTANTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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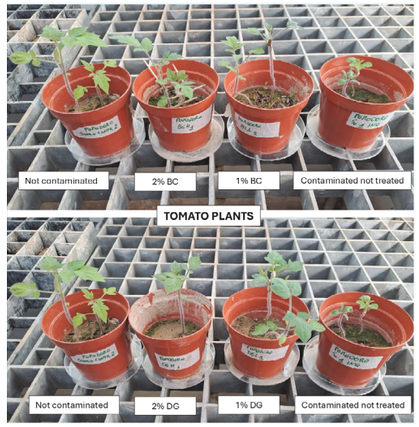
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In recent years, the awareness of the need to abandon fossil fuels to contrast climate change has encouraged the bioenergy sector. Thermochemical processes such as pyrolysis/gasification and biological processes such as anaerobic digestion release carbon-rich by-products that find useful applications in agriculture as soil amendments. In addition to improving soil quality and fertility, these materials can significantly contribute to mitigate soil pollution. This study explored an innovative and low-cost application of such materials for the elimination of organic soil pollutants. The approach seems particularly suitable for intensively exploited soils that are poor in organic matter and have contamination levels that preclude direct biological treatments such as bio- and phytodecontamination. A wood biochar (BC) and a mixed digestate (DG) at doses of 1 and 2% (w/w) were employed separately to remediate a multi-contaminated soil. A two-step procedure was used, consisting of adsorption of contaminants onto the materials and subsequent fungal degradation. The soil was artificially contaminated with the fungicide penconazole (PEN), the herbicide S-metolachlor (S-MET), and two endocrine disrupting chemicals, bisphenol A (BPA) and nonylphenol (NP), at an individual concentration of 2 mg kg-1. The adsorbents were distributed on a layer of tissue-non-tissue that was overlaid on the soil subjected to periodic watering. After 2, 6 and 12 d of exposure to the polluted soil, the adsorbents were removed. Analysis of contaminant residues in the soil showed a clear reduction in all treatments. After 12 d, the percentages of PEN, S-MET, BPA and NP adsorbed onto 2% BC were 84, 63, 94 and 21%, respectively, while they were lower onto DG and at 1% dose. To ascertain the reduced phytotoxicity of the treated soil, plant assays were performed. Compared to plants grown on untreated soil (control), all treatments increased the biometric parameters of the plants, e.g., 2% BC increased the dry biomass and height of tomato plants by 96 and 83%, respectively, and those of basil by 94 and 25%. The adsorbents exposed to the contaminated soil for 12 d were then inoculated with the soil-resident fungi Pleurotus eryngii, P. ostreatus and Irpex lacteus, separately, and incubated for 10 and 15 d under controlled conditions. At the end of the experiments, especially after the longer incubation, a significant reduction of contaminants was found. The overall results obtained encourage further investigations and may pave the way for future more ecological and economical procedures for the remediation of heavily contaminated soils.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS - This study contributes to the project PRIN 2022 PNRR titled “Microbially enriched biosorbents from waste recycling and soil-resident fungi as novel and sustainable tools to mitigate soil pollution by chemicals..”, financially supported by the European Union—NextGenerationEU—PNRR Mission 4, Component 2, Investment 1.1. CUP:H53D2301052000



Tomato plants grown on contaminated soil untreated (control) and after the treatments with biochar or digestate

GT 07 - 356 - F + P

NITROGEN TRACING FROM COVER CROPS TO MAIZE: N FATE IN THE SOIL-PLANT SYSTEM

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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In Mediterranean areas, irrigated maize systems are based on winter bare soil periods increasing nitrate leaching risk. Cover crops (CC) can improve N use efficiency (NUE). However, poor synchronization between N release dynamics and maize requirements can lead to a low NUE. The aim was to evaluate N fate from CCs, in the soil-plant system, in a sprinkler-irrigated maize cropping system using isotopic labeling.

Three CCs were analyzed: (i) spontaneous winter vegetation mainly based on Veronica persica L. and Capsella bursa-pastoris L. (spontaneous), (ii) rye (Secale cereale L. var. Poseydon) as cereal CC and (iii) faba bean (Vicia faba L. var. Axel) as legume CC. Three 1x1.5 m2 microplots were established for each treatment. One labeled with 15N (4 kg 98 atom% 15N ha-1) by ammonium sulphate (AS), another unlabeled, and a control plot (4 kg N ha-1) for each treatment with four replications. The aerial and below-ground CC biomass (ABMCC and RBMCC, respectively) were sampled before mechanical control. The ABMCC of labeled and unlabeled microplots was exchanged. Aboveground maize biomass, ABMMaize (grain and the rest aerial biomass, ABMRest) and root maize biomass (RBMMaize) were sampled at physiological maturity. N and 15N concentrations were determined in ABMCC, RBMCC, ABMMaize, and RBMMaize, as well as in the soil0-60cm (after CCs termination and post-harvest maize). Total Nitrogen (TNCC) and nitrogen recovery efficiency (NRECC) derived from CC to maize was calculated following [1].

The biomass and N uptake for CC and maize are shown in Figure 1A, 1B, 1C and 1D. The N recovered from ABMCC to maize was 62.1 kg N ha-1 (39.0 %), 9.6 kg N ha-1 (45.2 %), 40.2 kg ha-1 (25.0 %) for spontaneous, faba bean and rye CCs, respectively. The soil0-60cm recovered 102.2 kg N ha-1 (59.7 %), 10.6 kg N ha-1 (58.4 %), 97.5 kg ha-1 (57.8 %) for spontaneous, faba bean and rye CCs, respectively (Fig. 1E, 1F). N recovered in RBMCC+AS was practically negligible (Fig. 1G and 1H). The soil0-60 cm pool recovered a significant amount of CC N either from ABMCC or RBMCC+AS (Fig. 1F and 1H).

Faba bean growth was limited by low early-season rainfall, while spontaneous and rye vegetation contributed the most N to maize. N recovery from CCs was high in the soil-plant system, mostly retained in the soil. Further fractionated of this N pool could reveal mineral forms loss risk.

ACKNOWLEDGEMENTS

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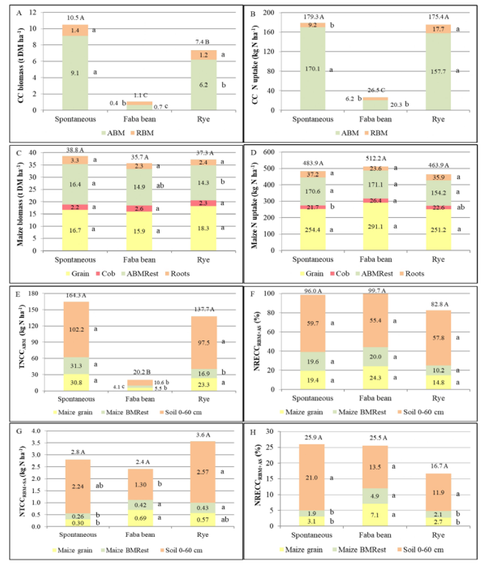


Figure 1. Cover crops (CCs) biomass (A) and N uptake (B) and maize biomass (C) and N uptake (D). Amount (E) and percentage (F) of N from above-ground CCs biomass (ABM_{CC}) recovered in maize grain and rest of biomass, BMRest (cob, straw, and roots). Amount (G) and percentage (H) of N from root CCs biomass plus residual ammonium sulphate not uptake by CC recovered in maize grain and BMRest. Note that N from CCs recovered in the soil (0–60 cm depth) just after maize harvest corresponds to total N. Lower-case letters show significant differences between treatments for a given fraction while upper-case letters show differences between treatments for the sum of fractions ($p<0.05$).



GT 07 - 413 - F + P

SHORT-TERM EFFECTS OF TORREFIED RAPESEED STRAW ON RYEGRASS GROWTH AND DISSOLVED SOIL ORGANIC CARBON

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Thermochemical conversion of agricultural residues is increasingly recognised as a climate-smart strategy to enhance soil fertility, sequester carbon, and valorise harvesting residues [1]. While pyrolyzed biomass (biochar) has been extensively studied over the past two decades, the effects of torrefied biomass (biotorr) on plant performance and soil properties remain largely unexplored, especially in European contexts [2]. This study aims to fill this gap by evaluating the early-stage agronomic potential of torrefied rapeseed straw and its influence on soil organic carbon dynamics. To this end, we produced torrefied straw at 230 °C (T230) and 280 °C (T280), and biochar at 400 °C (B400), and each was applied to the soil at a rate of 10 t ha^{-1}. We also established a treatment with fresh straw (FS) and a treatment with mineral fertilizer equivalent (NPK). A 4-week experiment was conducted in controlled conditions with Italian ryegrass (Lolium multiflorum Lam.) as a test crop. Results revealed that T280 significantly improved plant height and biomass relative to FS and T230 but remained less effective than B400 and NPK treatments. In addition, biomass production under T280 increased by over 100% compared to FS, while B400 outperformed all other organic treatments with increases exceeding 250%. Moreover, dissolved organic carbon (DOC) was significantly affected by treatment. Torrefied straw application induced strong DOC pulses at day 0, which decreased sharply by day 28, indicating rapid carbon release and transformation. Overall, torrefied straw, particularly at 280 °C, demonstrated an intermediate effect on agronomic performance most probably enhancing early plant growth through fast C mineralization [3]. These findings highlight the untapped potential of biotorr as a sustainable amendment, especially in systems aiming to balance short-term nutrient availability with long-term effects on soil functioning.

ACKNOWLEDGEMENTS

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GT 07 - 599 - F + P

UNDERSTANDING THE KEYS BEHIND A SUCCESSFUL SUBSTITUTION OF P MINERAL FERTILIZATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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There is a scientific agreement on the need to transition from mineral fertilization to bio-based fertilization recovering nutrients, especially phosphorus (P) from side streams. Despite the important effort of studying the performance of different P bio-based fertilizers, there are still important limitations. Raw material and revalorization techniques diversity combined with different edapho-climatic conditions restrains providing general recommendations that impulse this transition. A Pot experiment with two different physicochemical properties affecting P dynamics has been conducted to evaluate the performance of 11 bio-based fertilizers with different origins and revalorization techniques. BBFs can be grouped by compost BBFs, Plant by-products BBFs, Animal by-products BBFs, P-ashes, and P-precipitates. It was assessed not only the short-term but also the long-term effects of BBFs with two growing cycles (Wheat-sunflower). Most of the variables studied in the soil-plant system were affected by the BBF application, including enzymatic activities or microbial populations which were significantly correlated to the plant performance and the P extractions. Replacement value of fertilizers ranged from close to 0 to more than 100%, demonstrating that substitution of mineral fertilizers is not necessarily linked to a diminution of productivity. Interestingly, results are better explained by the main P forms in fertilizer than from the origin of the raw material or the revalorization technique. Main P form interaction with soil physicochemical properties also contributed to explaining the performance of the fertilizer supplying P to the crops. The results of this study provide insights that contribute to the successful transition from mineral fertilization to a bio-based fertilization in agroecosystems.

KEYWORDS

Bio-based fertilizers (BBFs), Phosphorus, soil, MNR

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GT 07 - 601 - F + P

SOIL ENZYME ACTIVITIES AND MICROBIAL COMMUNITIES AS INDICATORS OF SOIL HEALTH IN MANURE-AMENDED ORCHARD SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Animal manures are valuable organic amendments that can supply essential nutrients to crops, enhance soil organic matter, improve soil structure, and stimulate microbial activity. They offer a potential alternative to mineral fertilisers (MFs) when their fertiliser efficiency is ensured, and environmental loss is minimised. Partial substitution of MFs with animal manures has been shown to maintain crop production without increasing greenhouse gas (GHG) emissions. However, the impacts of such substitution on soil enzymes and microbial community, as well as the potential of these microbial properties as soil health indicators remain insufficiently explored. To address these gaps, this study investigated soil dehydrogenase (DHA), β-glucosidase (βG), and N-acetyl-β-glucosaminidase (NAG) activities, along with phospholipid fatty acids (PLFA) profiles in a Mediterranean apple orchard where MFs were partially replaced by cattle slurry (CS), acidified cattle slurry (ACS), cattle solid manure (CsM), and poultry manure (PM) over a three-year period. This study aimed to 1) evaluate the effects of manure application on soil enzyme activities and microbial community; 2) assess how manure types influence microbial properties; and 3) explore the potential of microbial properties as soil health indicators to reflect soil functions such as primary production and GHG emissions.

Results showed that the responses of soil enzymes to manure substitutions were both enzyme- and manure-specific. CsM and PM increased NAG activity, because their higher organic matter input led to higher soil organic carbon (SOC). ACS reduced DHA activity, likely due to the acidic conditions it promoted. PLFA analyses revealed greater fungal dominance in all fertilised treatments compared to unfertilised soil. βG activity was positively correlated with the abundance of fungi groups, suggesting that this enzyme is primarily derived from soil fungi. DHA was highly positively correlated with SOC and soil nutrients like N, P, and K, indicating its potential as a reliable indicator of soil fertility. A positive correlation was also observed between NAG activity and N_2O emissions, supporting its role as both a key player in and indicator of N cycling. However, no significant correlations were found between microbial properties and crop productivity. These findings suggest that microbial properties, particularly enzyme activities and PLFA profiles, hold promise as indicators of soil health for monitoring nutrient cycling and GHG emissions. However, their limited correlation with crop productivity highlights the need for integrated indicators when assessing overall agroecosystem performance. Although overall effects were moderate, manure substitution positively impacted soil microbiology, and should be adopted in sustainable fertilisation strategies for orchard systems.

ACKNOWLEDGEMENTS

Project Nutri2Cycle: H2020-SFS-30-2017 (Grant No 773682); LEAF (UIDB/04129/2020), and CEF (UIDB/00239/2020) funded by FCT.

GT 07 - 862 - F + P

GREEN WASTE COMPOST AS AN ECO-FRIENDLY ALTERNATIVE TO REMEDIATE SALT-AFFECTED SOILS IN MOROCCO

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil salinization is a significant environmental and agricultural issue affecting at least 400 million hectares worldwide (FAO, 2005). This phenomenon is more pronounced in Africa which contains 63% of the total world saline soils. Soils affected by salinity are characterized by high soluble salts concentrations and low levels of organic matter and nitrogen. Soil salinity impacts the physical, chemical and biological soil's properties, leading to the degradation of the soil structure, as well as a loss of its fertility. In Morocco, salinity is ranked as the second threat to crop production, after erosion. To restore soils impacted by salinization, the application of organic amendments is considered as a sustainable solution. In this context, this study aims to evaluate the use of green waste composts from the botanical garden for the rehabilitation of Moroccan saline soils. The experiment was carried out in a greenhouse at the National Institute of Agricultural Research (INRA) of Rabat. The experimental design was a completely randomized block, with three replications and twelve treatments. The composts chosen for this trial were produced at the botanical experimental garden of INRA and are as follows: C1 consisting of mixtures of green waste, straw, and sheep manure; and C2 taken from mixture of green waste and straw, each compost was applied at two different rates (R1 = 15 t/ha and R2 = 30 t/ha). Soil samples for the experiment were collected from the Bahira area, known for its saline soils, based on the Soil database of INRA on saline soils. Two salinity classes were tested: S1 : the highly saline soil class with electrical conductivity (EC) of 15.23 dS/m, the saline soil class represented by soil S2 with an EC of 6.1 dS/m, compared to a non-saline soil S3 (EC = 0.3 dS/m). A total of 36 pots, each containing 5 kg of soil, were used for this trial. The results showed a significant decrease in soil salinity for 30 t/ha rate of C1, which reduced (EC) of soil S2 from 6.1 to 2.77 dS/m. Likewise , the same rate also increased the available phosphorus content in all three soils, rising from 33 to 62 ppm for S1, from 56 to 90 ppm for S2, and from 15 to 39 ppm for S3. Furthermore, the same rate improved the exchangeable potassium content in soils S2 and S3. Regarding organic matter analysis, the application of 15 t/ha of compost C1 increased significantly the organic matter content from 1.57% to 2.46% for S2.

KEYWORDS

green waste, compost, salt affected soils, Morocco



GT 07 - 52 - P

EFFECTS OF NITROGEN FERTILISER TYPES ON SOIL N_2O, CO_2, AND NH_3 EMISSIONS IN OIL PALM PLANTATIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Nitrogen fertilisers are essential for maximising oil palm (Elaeis guineensis) productivity but are also major drivers of greenhouse gas (GHG) emissions. These emissions not only intensify climate change but also highlight inefficiencies in nitrogen utilisation, undermining the sustainability of fertiliser practices. This study evaluates the effects of different nitrogen fertiliser types on soil GHG emissions in a tropical mineral soil environment, with a focus on quantifying N_2O, CO_2, and NH_3 fluxes and understanding their temporal dynamics and emission patterns. The study was conducted in a 15-year-old oil palm plantation on a Fluvaquentic Dystrudepts soil. Four treatments were applied: urea, ammonium chloride, potassium nitrate, and a control with no nitrogen inputs. Each fertiliser treatment was applied at an equivalent of 1 kg nitrogen per palm within the palm circle. Soil GHG fluxes were measured using a closed static chamber method over a 65-day period, with gas concentrations analysed using a Gasmet GT5000 Terra FTIR gas analyser. Results showed distinct emission profiles for each fertiliser type. Urea produced the highest CO_2 emissions (811.37 g m^{-2}). In terms of N_2O emissions, potassium nitrate showed the highest fluxes (1.79 g m^{-2}), followed by urea (0.21 g m^{-2}) and ammonium chloride (0.17 g m^{-2}). Ammonia emissions were predominantly from urea via volatilisation (13.41 g m^{-2}), with negligible emissions from other fertiliser sources. The total CO_2-equivalent emissions were highest for potassium nitrate (1,008.38 g m^{-2}), followed by urea (868.49 g m^{-2}), ammonium chloride (823.14 g m^{-2}), and the control treatment, which contributed the lowest emissions (559.87 g m^{-2}). Temporal variations in emissions were observed, where peaks occurring within the first week following fertiliser application. These findings provide important insights into the environmental trade-offs associated with different fertiliser types, highlighting the need for strategic fertiliser selection and application practices to optimise nitrogen use efficiency and mitigate GHG emissions. By identifying fertilisers that balance both productivity and environmental sustainability, this study contributes to the development of more sustainable fertilisation practices to reduce the carbon footprint of oil palm cultivation.

GT 07 - 59 - P

COMBINED APPLICATION OF MINERAL FERTILIZER AND ACIDIFIED OR RAW PIG SLURRY AS A STRATEGY TO INCREASE P AVAILABILITY FOR PLANTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The use of pig slurry in its raw form contributes to an increase of organic matter content in soil as well as an increase in available nutrients for plants. However, slurry application to soil can lead to significant ammonia emissions (NH3) and, agriculture in Europe contributes to more than 92 % of emissions of this gas. Slurry acidification has been used to mitigate NH3 emissions; hence, the combined application of mineral fertilizers and acidified pig slurry could be a beneficial fertilizing strategy, namely regarding P supply to plants since acidification promote P solubilization in slurry. The aim of this study was to assess the impact of combined application of mineral fertilizer and acidified or raw pig slurry on nutrients removals by plants (with special emphasis on P) and soil properties.

The experiment was carried out in pots (1.7 kg of a sandy soil sieved at 2 mm). The treatments considered were: Control (C); Raw slurry at rate 1 (RS1) and rate 2 (RS2); Acidified slurry rate 1 (AS1) and rate 2 (AS2); Superphosphate (18% P2O5) rate 1 (MF1) and rate 2 (MF2); Raw slurry with superphosphate (18% P2O5) rate 2 (RS+MF) and Acidified slurry with superphosphate (18% P2O5) rate 2 (AS+MF). Application rates were 150 kg ha-1 P2O5 (rate 1) and 300 kg ha-1 P2O5 (rate 2). Concentrated H2SO4 was used to acidify the pig slurry until the target pH of 5.5. Top dressing fertilization with 0.05 g N/kg of dry soil was carried out in all treatments. The crop used was radish (Raphanus sativus L.) with 3 pre-germinated seeds per pot. The experiment consisted of a completely randomized design with four replications. At the end of the experiment, the main soil properties and enzymatic activity were assessed and the plants (leaf, tuber and roots) fully were characterized in terms of dry matter production and nutrients removal.

The RS1 and AS+MF treatments promoted a greater increase in dry matter of the leaves relative to C. In the tuber part, there were no significant differences with C ($p < 0.05$). As for the root part, treatments RS2, AS1 and AS+MF recorded higher dry matter values than C at the end of the experiment. There was no significant differences between treatments in terms of P uptake by the plants. No significant differences between treatments were observed regarding removal of K, Mg and P in the tuber. The combination of raw slurry with superphosphate (18% P2O5) favoured the increase in sulphur in the tuber compared to RS1. An increase of the P2O5 content in soil was observed at the end of the experiment for RS1, RS2 and RS+MF. The application of pig slurry led to an increase of the activity of the desidrogenase and urease. However, the higher activity of the acid phosphatase was observed in AS+MF.

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GT 07 - 60 - P

PIG SLURRY AND DERIVED PRODUCTS: MID-TERM EFFECTS ON YIELD, GRAIN QUALITY AND SOIL FERTILITY ON MEDITERRANEAN RAINFEED WINTER CROPS ROTATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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In the zones with high pig farms concentration, the excess of slurry cannot be applied on nearby land and the slurry must be treated to better allocate the nutrients produced. One of the simpler and most widely used method is the separation of the solid and liquid fractions of the slurry. A nutrient-poorer liquid fraction can be applied in the nearby fields and a more nutrient-concentrated solid fraction can be more efficiently exported to far-away fields. Most farmers value the low cost and easy maintenance of the method when compared with other alternatives [1]. When repeatedly applied, these organic fertilizers may induce changes on some soil parameters different from those produced by the untreated slurry. In this study we quantified the mid-term effects of the application of these organic fertilizers on yield, grain quality, and soil fertility.

We carried out a six-year field trial using raw pig slurry (PS), liquid fraction (LF) and solid fraction (SF) of pig slurry, obtained using a press screw separator, to fertilize a rainfed winter cereal rotation under a semi-humid Mediterranean climate on a moderately deep, calcareous, loamy soil. All treatments were applied at a rate of nitrogen (N) of 170 kg ha-1 yr-1. The mean yearly yields of both wheat and barley were higher for the LF treatment and lower for the SF, although no statistically significant differences between treatments were observed. Grain protein content of wheat and barley was also non-significantly higher for the LF treatment when compared with the SF treatment. Both results are probably due to the higher availability of N in the case of LF.

After the experiment, the top-soil organic carbon content was statistically significantly higher (p-value: 0.002) in the treatments where SF had been repeatedly applied as fertilizer (1.35 %) than when LF had been used (1.03 %). It is claimed that LF obtained from press screwing can be used as a nutrient-equilibrated organic alternative for soils that have a high P content [2]. In this experiment, P and K top-soil contents increased for all treatments compared to the initial soil values, with the higher values obtained in the treatment where PS was repeatedly applied and the lower values when LF was used, even though the differences observed where statistically non-significant.

Due to its different properties, LF and SF may be better suited for different uses. While LF is better used as a fertilizer and has a N/P ratio better balanced for plant nutrition, the SF has demonstrated its capacity of increasing the soil organic carbon and may be a better choice for farms that have degraded soils with low organic carbon content and want to improve the soil quality.

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GT 07 - 68 - P

EFFECTS OF RICE-STRAW INCORPORATION AND WATER MANAGEMENT ON NITROGEN DYNAMICS AND GREENHOUSE GAS EMISSIONS DURING RICE CULTIVATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Rice cultivation is a significant source of greenhouse gas (GHG) emissions, particularly methane (CH_4) and nitrous oxide (N_2O), which are influenced by rice straw management and soil water conditions. This study examines the effects of rice straw incorporation on soil nitrogen transformations and GHG emissions under continuous flooding and alternate wetting and drying irrigation. A field experiment was conducted at the Ankeng Experimental Farm of National Taiwan University, comparing three treatments: rice-straw removal (-RS), rice-straw incorporation (+RS), and rice-straw cover (RS cover). Soil water was collected at certain time intervals to analyze chemical compositions, including dissolved organic carbon and inorganic nitrogen species, while CH_4 and N_2O fluxes were continuously monitored using a multichannel automated chamber system. Results showed that straw incorporation and cover increased soil carbon concentrations, leading to elevated CH_4 emissions, particularly under continuous flooding. N_2O emissions peaked 3–7 days after fertilization, with the highest emissions observed in the RS cover treatment, followed by +RS, and the lowest in -RS. The decomposition of rice straw contributed to nitrogen availability in paddy soil, which subsequently underwent denitrification. These findings underscore the need for optimized straw and water management strategies to mitigate GHG emissions while maintaining soil fertility in rice-based agroecosystems.

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Research funding for this study was provided by the Agriculture and Food Agency, Ministry of Agriculture, Taiwan.



GT 07 - 110 - P

NUTRIENT RESOURCE MANAGEMENT AND POLICY OF REGIONAL STAKES HOLDER IN SADO CITY, NIIGATA, JAPAN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Introduction

The Government of Japan and the Ministry of Agriculture, Forestry and Fisheries (MAFF) actively encourage the promotive use of phosphorus (P) and other nutrient components found in unused organic and inorganic waste materials. Sewage and food waste are regarded as important underutilized fertilizer resources. Their utilization as compost and/or as recovered nutrients from these wastes is aimed at partially substituting chemical fertilizers for food and feed production.

Sado City in Niigata Prefecture cultivates most of its paddy rice fields as Specially Cultivated Agricultural Products, in an effort to protect the Japanese Crested Ibis, a national monument. Under Japanese regulations, Specially Cultivated Agricultural Products are defined as crops grown with chemical fertilizers and synthetic agrochemicals reduced to less than half of the prefecture's standard guidelines. Such products account for only 4% (120,000 hectares) of Japan's farmland. Therefore, it can be said that Sado City demonstrates a high level of environmental awareness in its agricultural practices.

If the safety of sewage sludge compost is confirmed in Sado City and it is utilized for food production, this could represent a valuable step forward for other regions considering the use of sewage sludge compost.

The aim of our study is to evaluate how sewage sludge compost could reduce the use of chemical fertilizers through material flow analysis in Sado City. The target nutrient components are nitrogen (N), P, and potassium (K).

NPK flow in Sado City

The estimated NPK flow in Sado City is illustrated in Figures 1. The largest inputs of NPK to Sado City are fertilizers, amounting to 338 Mg N, 157 Mg P, and 293 Mg K for food and feed crops. More than 84% of NPK fertilizers are applied to paddy rice. Approximately half of N fertilizer used for paddy rice is derived from organic sources, while the other half is synthesized. The largest NPK output from Sado City is paddy rice, followed by livestock products (veal cattle). The ratios of self-supplied food and feed for NPK in Sado City are 26% for N, 30% for P, and 44% for K. Although livestock manure is applied to feed and food crops, the contribution of manure NPK accounts for only 7% for N, 4% for P, and 3% for K compared to the total NPK input for food and feed crops.

Human waste is processed at sewage treatment centers, where NPK is removed as sewage sludge. If all sewage sludge, along with a portion of food refuse, is mixed and composted, the resulting compost is estimated to contain 37 Mg N, 17 Mg of phosphorus, and 11 Mg of potassium. These amounts account for less than 10% of the combined fertilizer and manure application.

Paddy rice cannot receive the compost due to regulations governing Specially Cultivated Agricultural Products. Farmers, however, are willing to apply the compost to non-food crops, such as flowers and feed crops, to confirm its safety. Based on our estimates, feed crops currently receive 8 Mg N, 4 Mg P, and 6 Mg K from fertilizers. Therefore, the compost could sufficiently replace fertilizers. Once the compost's safety for soil and other environmental factors is verified, it could be utilized for food crops, such as beans and orchards, as a substitute for part of the 27 Mg N, 12 Mg P, and 20 Mg K currently supplied by fertilizers.

Conclusion

Promising developments have emerged in certain regions of Japan, such as Saga City in Saga Prefecture and Kagoshima City in Kagoshima Prefecture, where sewage sludge compost is utilized for food crop production. Although the quantity of sewage sludge and its composted material in Sado City is smaller compared to these cities, it would still be sufficient for application to feed crops and food crops, excluding paddy rice. Once the safety of sewage sludge compost is confirmed in the region, its promotive use could contribute to increasing the self-sufficiency rate of fertilizer in Japan.

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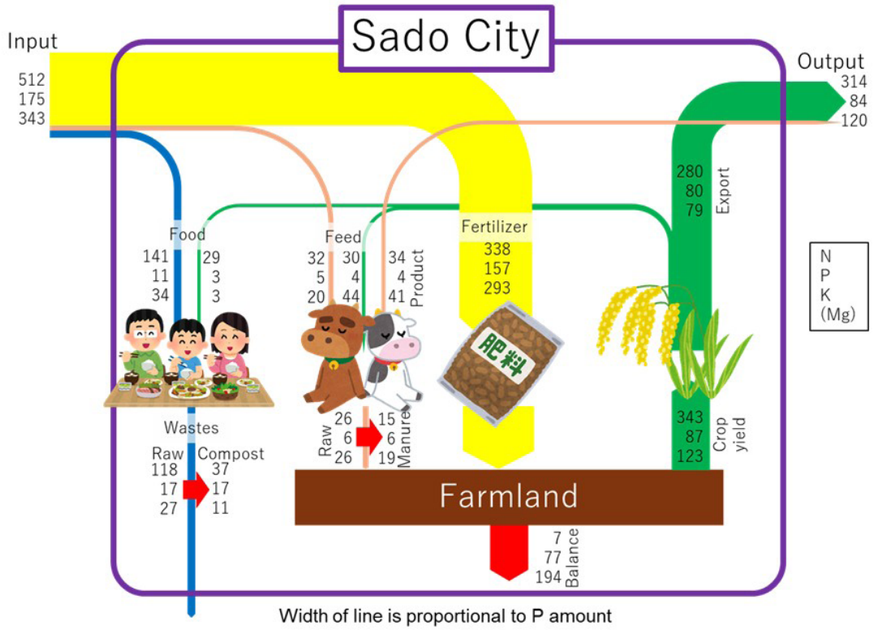


Fig. 1. NPK flow in Sado City



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GT 07 - 125 - P

CHEMICAL AND MICROBIOLOGICAL STABILITY OF DIGESTATE DURING STORAGE: IMPLICATIONS FOR FERTILIZER VALUE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 02. SOIL PHYSICAL CHEMISTRY

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Digestate, the nutrient-rich byproduct of anaerobic digestion, has gained increasing attention as a sustainable alternative to synthetic fertilizers. However, its agronomic value and environmental impact are closely tied to its in-time stability - a measure of how the chemical and microbiological properties of digestate evolve post-production. An understanding of the chemical and microbiological stability of digestate is important for the optimization of nutrient recovery and availability. This understanding also enhances the potential applications of microorganisms contained within the digestate. This study investigates the in-time chemical and microbiological stability of digestate produced from molasses-based anaerobic digestion, monitored over an 8-week storage period. The goal is to clarify how storage influences digestate quality and to assess its potential effectiveness as an organic fertilizer. Laboratory analyses included elemental composition assessment using ICP-OES and CHNS analysis, colorimetric determination of nitrate (NO_3^-) and ammonium (NH_4^+) ions, as well as targeted amplicon sequencing of the 16S rRNA (V3–V4 regions) and ITS regions to characterize the bacterial and fungal communities, respectively. The chemical composition of the digestate remained generally stable over the 8-week storage period, with the exception of nitrate (NO_3^-) levels, which showed a significant increase. Microbial analysis revealed a divergent trend in community diversity: bacterial diversity increased during storage, while fungal diversity declined. By the end of the experiment, a notable shift in bacterial community structure was observed, characterized by a significant decrease in Firmicutes and an increase in Proteobacteria, Verrucomicrobiota, and Synergistota. In the fungal community, the most pronounced change was a marked reduction in the relative abundance of Sordariomycota. The observed increase in nitrate levels during storage suggests enhanced nitrogen availability in the form most readily accessible to plants, which may improve the fertilizing potential of the digestate. The increase in bacterial diversity, along with the enrichment of specific bacterial groups such as Proteobacteria, Verrucomicrobiota, and Synergistota, may contribute positively to soil microbial activity and nutrient cycling upon application. Overall, the results indicate that while chemical stability is largely maintained, storage can influence the microbiological quality of digestate in ways that may impact its agronomic performance.

ACKNOWLEDGEMENTS

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GT 07 - 154 - P

EFFECTS OF LOW-MOLECULAR-WEIGHT ORGANIC ACIDS ON PHOSPHORUS ADSORPTION- DESORPTION CHARACTERISTICS AND PHOSPHORUS FRACTIONS IN SALINE-ALKALI SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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In the coastal saline-alkali soils of the Bohai Rim region, the abundance of calcareous components (e.g., calcium carbonate) and high pH (>8) lead to strong phosphorus adsorption and rapid conversion into insoluble calcium phosphate salts. Low-molecular-weight organic acids (LMWOAs), particularly oxalic and citric acids which exhibit superior phosphorus-solubilizing capacity and ubiquitous presence in soils, serve as a vital phosphorus-mobilizing strategy for plants and microorganisms. However, their mechanisms in coastal saline-alkali soils remain insufficiently studied. This study employed batch experiments and a modified Hedley phosphorus classification method to investigate the effects of different concentrations of oxalic acid (C5: 5 mmol.kg-1, C10: 10 mmol.kg-1, C50: 50 mmol.kg-1) and citric acid (N5: 5 mmol.kg-1, N10: 10 mmol.kg-1, N50: 50 mmol.kg-1) on the adsorption-desorption characteristics and transformation of phosphorus in coastal saline soils. The results showed that: 1) Oxalic acid demonstrated a stronger ability to inhibit phosphorus adsorption and activate phosphorus compared to citric acid. As the concentration of organic acids increased, the effect improved. Both oxalic and citric acids promoted phosphorus desorption and activation by competing for binding sites with phosphate ions via $-COO^-$. 2) C50 promoted the transformation of stable Pi to labile Pi in soil after 3 and 30 days, increasing labile Pi significantly by 3.48% and 2.59%, respectively. N50 promoted the transformation of labile Pi and stable Pi to moderately labile Pi after 3 days, resulting in a significant increase of 1.33% in moderately labile Pi. All treatments showed a trend of promoting the transformation of moderately labile Po to labile Po. 3) C10, C50, and N50 increased the contents of available phosphorus in the soil. However, the effectiveness of low-molecular-weight organic acids showed a time-dependent pattern. In saline-alkali soils, the effects began to diminish after 3 days, with citric acid losing effectiveness completely by day 10, while oxalic acid remained effective until day 30. 4)Soil adsorption capacity was significantly positively correlated with D.HCl-Pi, whereas desorption capacity was significantly negatively correlated with D.HCl-Pi and positively correlated with $NaHCO_3$- Pi and H2O-Pi. On phosphorus fractions, NaHCO3-Pi was significantly positively correlated with D.HCl-Pi, and H2O-Pi was significantly negatively correlated with NaOH-Pi.

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GT 07 - 161 - P

IMPACT OF TORREFIED RAPESEED STRAW APPLICATION ON EARTHWORMS GROWTH AND AVOIDANCE/PREFERENCE BEHAVIOUR.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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There is growing interest in torrefied biomass (biotorr) as a soil amendment [1], but unlike biochar, its effects on soil functioning are poorly documented. In particular, although biotorr is expected to affect soil properties in a similar way to biochar [2], there is a significant knowledge gap regarding its effects on soil fauna, particularly earthworms. Here, we conducted ecotoxicological and avoidance/preference tests on two earthworm species to determine how rapeseed straw biotorr produced at two temperatures affect earthworm survival, growth and behavioral responses compared to fresh straw and biochar produced at 400°C. Additionally, we included pre-washed variants of each treatment to evaluate if the potential toxicity of biotorr to earthworms could be related to the solutes removed by the prewash. Our results showed no impact of amendment application on earthworm survival rate. However, we noted significant differences concerning the amendment effects on earthworm growth. Earthworms were biggest in treatments with application of 230°C biotorr and fresh straw compared to 280°C biotorr and control treatments. Biotorr application did not induce earthworm avoidance. In addition, we observed earthworm preference for fresh straw compared to unwashed 280°C biotorr and 400°C biochar. Pre-washing significantly increased biotorr attractiveness for earthworms compared to fresh straw, but had no impact on biochar, suggesting that biotorr contains soluble compounds affecting soil fauna. We conclude that soil amendment with prewashed biotorr may be more suitable than biochar and fresh residues to foster earthworms.

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GT 07 - 177 - P

VALORIZING BIOCHAR AS A FERTILIZER IN MEDITERRANEAN AGRICULTURE: EFFECTS ON SOIL FERTILITY, NITROGEN DYNAMICS, AND SOIL GREENHOUSE GAS EMISSIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Biochar is increasingly considered a promising amendment to improve soil fertility and reduce the environmental impacts of agriculture. This is particularly relevant in Mediterranean semiarid regions, where soils often suffer from low organic matter, limited nutrient retention, and high risk of degradation under intensive cropping systems. To explore its agronomic potential, a field experiment was established at the research farm of the Aula Dei Experimental Station (EEAD-CSIC, Zaragoza, Spain) over two wheat-growing seasons (2025–2026). The soil is a Typic Xerofluvent with silty loam texture, basic pH, low carbon and nitrogen contents, and more than 30% $CaCO_3$. The experiment consists of six treatments: control (C), mineral fertilizer only (MF), low biochar (2 t/ha, LB), medium biochar (6 t/ha, MB), and combinations LB+MF and MB+MF.

Soil nitrogen dynamics showed that MF and LB+MF treatments led to the most pronounced increases in nitrate availability, over 3 to 4 times higher than the control, indicating greater risk of leaching. Biochar-only treatments displayed more stable N profiles with lower peaks, suggesting better retention. In terms of soil greenhouse gas emissions, the MF treatment increased both CO_2 and N_2O emissions compared to the control. In contrast, the combination of medium-dose biochar with fertilizer reduced cumulative N_2O emissions by over 140% relative to MF alone, while moderating CO_2 release. These preliminary outcomes suggest that moderate biochar doses combined with mineral fertilizer may support more sustainable nitrogen management in calcareous Mediterranean soils.



GT 07 - 190 - P

IMPACT OF EIGHT FERTILIZING RESIDUAL MATERIALS ON CORN NUTRITIONAL BALANCE AND YIELD: A FIELD STUDY ON TWO EXPERIMENTAL SITES IN EASTERN CANADA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Some residual materials possess desirable agronomic properties, such as high mineral content or great organic matter content and are thus referred to as fertilizing residual materials (FRMs). While the impact of FRMs on crop yield has been studied sparsely in cold climate such as Eastern Canada, their effects on crop nutritional balance remain largely unexplored. This study aims to evaluate the effects of eight FRMs on corn yield and nutritional balance using the Compositional Nutrient Diagnosis (CND) method. Fertilization treatments included a complete mineral fertilizer (M3) and combinations of mineral fertilizers with one of the following FRMs: granular sewage sludge (GSS), sewage sludge ash (SSA), deinking paper sludge (DPS), organic waste digestate (OWD), sewage sludge digestate (SSD), organic waste compost (OWC), sewage sludge compost (SSC), and untreated sewage sludge (SS). FRMs were applied to meet one-third of the nitrogen or the full phosphorus requirement of corn. The experiment occurred on two sites: heavy texture soil (S1) and medium texture soil (S2). Silage corn (2022) and grain corn (2023) yields were significantly higher at S2 than at S1 ($p<0.05$). At both sites and years, all treatments containing FRM produced a similar yield to the M3 treatment (10.55Mg ha-1 and 11.18Mg ha-1 at S1 and S2, respectively). All treatments produced balanced (CND-r2 < 11,0) grain corn at S2. OWC, DPS, and SSC treatments even produced a crop more balanced than the M3 treatment with CND-r2 of 2.8, 2.9 and 3.9, respectively. However, only the two digestates produced balanced corn at S1 with CND-r2 of 10.4 and 11.0, respectively. These findings highlight the potential of FRMs to partially substitute mineral fertilizers without yield loss while maintaining crop nutritional balance, particularly on soil with medium texture.

GT 07 - 201 - P

DEVELOPMENT AND APPLICATION OF A REUTILIZATION SYSTEM FOR VEGETABLE SEEDLING CULTURE MEDIUM IN TAIWAN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Taiwan's vegetable industry, with a total cultivation area exceeding 10,000 hectares, heavily relies on seedling propagation, but some crops like cucumber and tomato often need to be grafted to enhance disease resistance and reduce cultivation challenges. However, the primary culture medium used in seedling nurseries is imported peat moss, which has become increasingly costly due to supply issues, phytosanitary measures, and rising international shipping expenses, accounting for approximately 10%–15% of nursery operational costs. The aim of this study was to introduce a culture medium reutilization system. The system involved machinery, including crushers, separation sieves, steam sterilization boilers, vertical steam mixing sterilizers, and medium mixing equipment, to process discarded root medium and seedlings, which constitute about one-third of the total medium only used in the 12 to 25 day seedling grafting process. The findings of this study indicate that the reutilized medium exhibits a more neutral pH, which demonstrably promotes higher germination rates compared to new medium. In cucumber and tomato, the quality of seedlings grown in the reutilized medium is comparable to those grown in new medium. The adoption of this system is estimated to increase medium utilization efficiency by over 33%, offering a sustainable solution for waste reduction and cost savings in vegetable seedling production. This innovation aims to establish a new vegetable seedling production model for Taiwan, mitigating medium shortages and promoting recycling efficiency.



GT 07 - 215 - P

AUTOMATIC FERTIGATION SYSTEM BASED ON EC SENSOR MONITORING FOR PRECISION MANAGEMENT OF CROP NUTRIENTS IN SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The current method of supplying nutrients required for plant growth follows predetermined nutrient prescriptions, regardless of soil characteristics or the growth stage of the plants. However, to optimize nutrient supply for plant growth without causing environmental pollution from excessive nutrient application, it is essential to monitor soil nutrients in real time. This study focuses on the development of a system that diagnoses nutrient levels based on the electrical conductivity (EC) of soil and automatic supplies of nitrogen and potassium using a fertigation system. The added amount of urea and potassium chloride was sequentially increased in the soil, while monitoring the EC using sensors. A strong positive correlation (correlation coefficient >0.89) was observed between the amount of added fertilizer and the EC sensor readings. Based on this result, the amount of urea and potassium chloride required to increase the EC by 0.1 unit was calculated. Subsequently, in the pepper field, fertilizers were supplied using an automatic fertigation system, and the changes in the EC sensor readings were monitored. The available nutrient contents such as N, P and K in the soil and the EC values showed a positive correlation with the EC sensor values, indicating that precision nutrient supply using automatic fertigation system based on EC sensors is feasible.

ACKNOWLEDGEMENTS

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GT 07 - 217 - P

ALTERNATIVE FERTILIZERS SUSTAIN MAIZE YIELD AND PROMOTE BIOLOGICAL SOIL HEALTH: RESULTS FROM A THREE-YEAR FIELD TRIAL IN SOUTHEASTERN SPAIN.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Agroecosystems, which occupy around 40% of terrestrial land, are vital for food security and provide essential ecosystem services like nutrient cycling and soil structure maintenance. However, intensified fertilization has caused nutrient imbalances, environmental degradation, and increased costs. Recycled fertilizers derived from compost, sewage sludge, and struvite offer a promising alternative to conventional mineral fertilization by enhancing soil health and supporting sustainable crop production. In a three-year field experiment conducted in a semiarid Mediterranean agroecosystem (Santa Ana, Spain), we assessed the impact of organic, organomineral, and mineral fertilizers on soil microbial biomass, enzymatic activities, and maize agronomic performance. Results showed that organic and organomineral treatments significantly improved microbial biomass -as estimated with fatty acids-, particularly bacterial communities, and increased soil organic C content and the C:N ratio over time. Enzyme activities, especially urease, also increased in organomineral treatments. Although no significant differences in maize yield were observed across treatments, Random Forest analysis identified microbial biomass, phosphatase and β-glucosidase activities, and soil organic matter as key predictors of seed germination and yield performance. Our findings suggest that combining organic and organomineral fertilizers can enhance soil biological health while maintaining crop productivity, representing a cost-effective and environmentally sound strategy aligned with the goals of sustainable agriculture.

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GT 07 - 254 - P

DYNAMICS OF BACTERIAL AND FUNGAL COMMUNITIES IN HYDROCHAR-AMENDED SOILS UNDER A CROP ROTATION SYSTEM

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Maintaining healthy and functionally diverse soil microbiota is critical for the sustainability of agroecosystems, as bacteria and fungi mediate key biogeochemical processes. Crop rotation systems are widely recognized for their ability to enhance soil quality and microbial diversity, while organic soil amendments such as hydrochar (HC) are gaining attention for their potential to support sustainable agricultural practices. However, little is known about how long-term HC application interacts with crop rotation regimes to shape microbial community dynamics over time.

To explore this knowledge gap, we applied a metagenomic framework to investigate both short- and long-term effects on phylum-level microbial community structure and overall diversity in soils subjected to different treatments: conventional mineral fertilization (NPK), HC amendments, and untreated controls (CTR). A 330-day greenhouse pot trial was established to simulate a crop rotation system, starting with sunflower followed by wheat, with a fallow period in between. Soils were treated either with two HC doses (3.25 and 6.5 t ha^{-1}) or with mineral fertilizer (NPK) applied at equivalent nitrogen rates. Both well-irrigated and water-deficit scenarios were included.

Soil samples were collected from the 0–15 cm layer at two time points—day 77 (end of sunflower cultivation) and day 330 (end of wheat cultivation)—for high-throughput sequencing of 16S rRNA (bacteria) and ITS (fungi) regions. Bioinformatic processing enabled the determination of phylum-level relative abundances, as well as alpha-diversity metrics. Community composition patterns (beta-diversity) were analyzed using Bray–Curtis dissimilarities and visualized through a Principal Coordinates Analysis (PCoA).

At both time points, clear differences in microbial community diversity patterns were observed across the soil treatments. Over the course of the experiment, the number of observed bacterial Operational Taxonomic Units (OTUs) generally increased between sampling times, whereas the number of fungal OTUs consistently declined. In the short term, HC application had a marked impact on the relative abundance of several dominant bacterial phyla—an effect that was not sustained in the long term. Notably, soils amended with HC-6.5 under well-irrigated conditions consistently exhibited reduced fungal diversity and a lower number of observed OTUs at both sampling time points.

These results suggest a short-term modulatory effect of HC on bacterial communities, potentially influenced by crop species, application dose, and irrigation type. In the short to long term, the negative impact on fungal diversity followed a similar trend over time, suggesting greater sensitivity of fungal communities to HC or a lack of influence of the crop type. These findings highlight the importance of considering microbial communities when evaluating alternative sustainable agricultural practices, as they are key to soil health.

GT 07 - 259 - P

ASSESSING THE FERTILIZING POTENTIAL OF TWO TANNERY BIO-WASTES THROUGH SHORT-TERM SOIL INCUBATION AND PLANT RHIZOSPHERE BIOASSAY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The tannery industry is a significant global manufacturing sector, producing over 4 million tons of tannery bio-wastes (TBWs) annually[1], and to reintegrate TBWs into the productive cycle offers a significant alternative to landfill disposal. Despite TBWs are rich in organic matter, nitrogen (N), and carbon (C) [2, 3] they pose important environmental risks, such as the presence of heavy metals like chromium (Cr) that can be released into the environment [4]. This study aimed at evaluating the fertilizing potential of two TBWs-based fertilizers through a complementary laboratory-scale approach by using a short-term soil incubation experiment and the Rhizotest (ISO1698:2015) bioassay.

Two TBW-based fertilizers, Tannery Sludge (TS) and Integrated Leather Meal (ILM), were subjected to 42 days of soil incubation and to Rhizotest bioassay. Nitrogen release, chemical and biochemical indicators were assayed after the soil incubation. Tomato plants uptake of heavy metals and rhizosphere enzyme activities were assayed after Rhizotest.

TS and ILM released 11% and 35% of their total N content respectively, with TS acting more as a slow-release fertilizer [5]. Heavy metal contamination was negligible, except for Cr, which however remained in the soil in its trivalent form and was not absorbed by plants. Rhizotest allowed to highlight that TS and ILM stimulated broad and specific enzyme activities in the rhizosphere soil.

This complementary approach enabled rapid, reproducible, and sensitive characterization of organic fertilizers produced from TBWs, which have the potential to be employed as organic fertilizers safely.

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GT 07 - 262 - P

VALORISATION OF BEACH WRACK BIOMASS AS A SUSTAINABLE SOIL AMENDMENT: COMPOST QUALITY ASSESSMENT AND AGRICULTURAL POTENTIAL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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The coastal ecosystems of the Baltic Sea are increasingly subjected to multifaceted environmental pressures stemming from both anthropogenic activities and natural processes. One of the consequential outcomes of these pressures is the accumulation of beach wrack—organic material composed primarily of marine algae, seagrasses, and associated detritus—along shorelines. Although commonly perceived as a waste product or local nuisance due to its odor and decomposition-related emissions, beach wrack represents an underutilized yet potentially valuable biomass resource. Its presence is linked to broader environmental concerns, including coastal eutrophication, nutrient imbalances, and greenhouse gas emissions. However, when strategically collected and processed through composting, beach wrack may serve as a sustainable bioresource with agronomic applications.

This study aimed to evaluate the composting potential of beach wrack mixed with various organic co-substrates and to assess the physicochemical quality and agronomic value of the resulting composts. Four compost formulations were developed using beach wrack combined in different proportions with straw, grass clippings, farmyard manure, and microbial inoculants to optimize microbial activity and degradation kinetics. The composts were assessed based on nutrient composition and contamination parameters including heavy metals and phytotoxicity. Among the treatments, the compost consisting of beach wrack with straw, grass, and manure demonstrated the most favorable characteristics, exhibiting elevated levels of essential plant nutrients (N, P, K), increased concentrations of humic substances, and enhanced humification of hydrophilic organic components. This formulation also showed reduced levels of potentially hazardous elements, indicating low contamination risk and suitability for soil application. The improved structural stability and organic matter quality of this compost suggest enhanced soil fertility, increased nutrient retention, and potential to improve plant tolerance to abiotic stresses. The findings support the feasibility of transforming beach wrack from an environmental burden into a value-added agricultural input, contributing to nutrient cycling, soil health restoration, and circular bioeconomy principles. This approach not only mitigates ecological impacts on coastal environments but also fosters the development of resilient and sustainable agroecosystems.

GT 07 - 268 - P

BIOGAS RESIDUES IN THE BATTLE FOR TERRESTRIAL CARBON SEQUESTRATION IN THE GRASSLAND SOILS OF THE GREATER REGION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

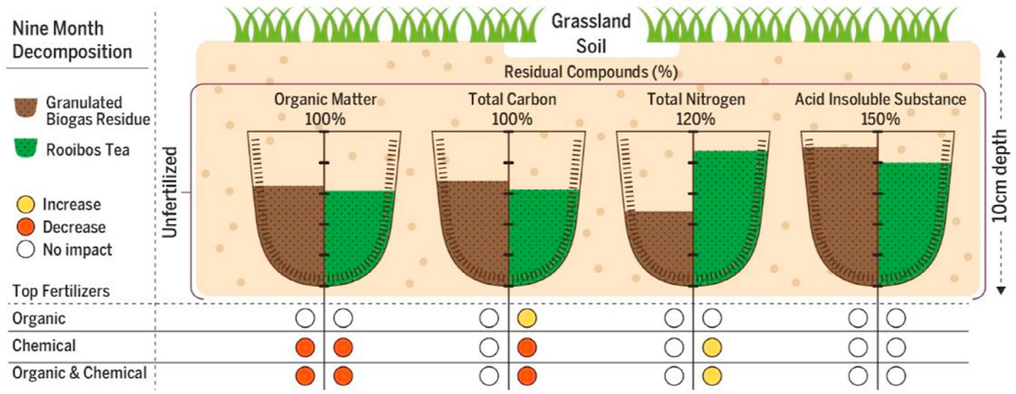
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The recycling of biogas residues resulting from the anaerobic digestion of organic waste on agricultural land is among the means to reduce chemical fertilizer use and combat climate change. In this in sacco decomposition study we investigate (1) the potential of the granulated biogas residue fraction to provide nutrients and enhance soil carbon sequestration when utilized as exogenous organic matter in grassland soils, and (2) the impact of different nitrogen fertilizers on the organic matter decomposition and nutrient release processes. The experiment was conducted in two permanent grasslands of the Greater Region over one management period using rooibos tea as a comparator material. The decomposition and chemical changes of the two materials after incubation in the soil were assessed by measuring the mass loss, total carbon and nitrogen status, and fibre composition in cellulose, hemicellulose and lignin. Granulated biogas residue demonstrated resilience and a higher response uniformity when exposed to different nitrogen fertilizers, as opposed to the comparator material of rooibos tea. However, the magnitude of fertilizer-type effect varied, with ammonium nitrate and the combinatorial treatment containing urea leading to the highest organic matter loss. The findings of this study suggest that granulated biogas residue is a biofertilizer with the potential to supply nutrients to soil biota over time, and promote carbon sequestration in grassland soils, and thereby advance agricultural sustainability while contributing to climate change mitigation.





GT 07 - 292 - P

IMPROVING NUTRIENT BALANCE IN KOREA THROUGH SCENARIO-BASED APPROACHES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Nitrogen (N) and phosphorus (P) are essential macronutrients for crops and all living organisms. While nutrient input plays a critical role in sustaining crop productivity in agricultural systems, excessive application beyond crop demand can result in nutrient loss, leading to environmental issues such as water eutrophication and greenhouse gas emissions, as well as economic inefficiencies. Nutrient balance, defined as the difference between nutrient inputs(primarily fertilizers and livestock manure) and nutrient outputs(crop uptake), serves as a key indicator for monitoring nutrient flows and potential surpluses in arable land. In 2022, Korea recorded a nitrogen balance of 240 kg N ha^{-1} and a phosphorus balance of 44 kg P ha^{-1}, both among the highest across the 35 OECD member countries. To address these nutrient surpluses, we evaluated three national-scale mitigation scenarios: 1) Optimized fertilizer application based on soil testing, 2) Reduction in livestock numbers, and 3) Improvement of livestock manure treatment rates. Each scenario was evaluated to determine its effectiveness in reducing nutrient balance across Korea's agricultural land. The simulated impacts showed a potential reduction of nutrient balance by up to 20%(Scenario 1), 25%(Scenario 2), and 70%(Scenario 3), respectively. These results highlight the significant potential of improving livestock manure management in reducing nutrient overloads. Moreover, complementary strategies, such as converting livestock manure into a renewable energy source, can further contribute to sustainable nutrient management and national carbon neutrality goals. Given the high nutrient surplus driven by livestock-related inputs, Korea's nutrient management strategies should prioritize manure treatment enhancement, livestock density control, and circular nutrient use practices. This study provides a policy-relevant framework for improving nutrient efficiency and mitigating environmental risks associated with nutrient overloading.

GT 07 - 338 - P

MICROBIOLOGICAL PROPERTIES OF FERTILIZERS BASED ON COFFEE BY-PRODUCTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Coffee industry produces more than 10 million tons of dry residues as by-products annually, most of which are discarded. In recent years, the practice of applying coffee by-products such as coffee chaff, silverskin or coffee husk (CH) and spent coffee grounds (SCG) as mulch and organic fertilizer has become widespread. Among possible alternative ways of their utilization, the application of previously composted or partially decomposed CH and SCG to the soil improves plant growth. A similar effect can be achieved by vermicomposting. The properties of composts vary greatly depending on the region, the raw materials used and the methods of their preparation, which is why it is necessary to select the optimal mode of production and application of fertilizers in each specific region, taking into account its characteristics.

We performed composting and vermicomposting of CH and SCG mixed with manure in various proportions (0, 25, 50, 75, 100% of CH or SCG) for 30 days. During composting, a mixture of plant growth promotion bacteria (PGPB) was added: Azotobacter chroococcum, Agrobacterium sp., Arthrobacter globiformis, Bacillus subtillus, Enterobacter sp., Rhisobium sp. Vermicomposting was carried out with Eisenia fetida andrei worms. Upon completion of (vermi)composting, we assessed the microbiological characteristics of the fertilizers using community-level physiological profiling (CLPP), bacteria culturing and identification.

According to CLPP data, all studied microbial communities were characterized by very high potential metabolic activity and functional diversity. In particular, the Shannon index varied from 5.18 to 5.33, and microbial communities consumed from 43 to 46 substrates out of 47 studied. The number of culturable bacteria in most (vermi)compost samples was very high, about 10^11 CFU/g. In the variants with a low (25%) content of coffee by-products, the number of culturable bacteria was 10^10 CFU/g.

Among the cultured bacteria in all the studied samples, Bacillus spp. were the most abundant group. Many bacteria of this genus are PGPB. In most samples, Pseudomonas spp. were found among the dominants, which are also known like PGPB. Bacteria of the genera Micrococcus, Chromobacterium, Arthrobacter, Flavobacterium, Aeromonas, Alcaligenes, Acinetobacter and Streptomyces were found as dominants and subdominants, and the highest frequency of their occurrence was noted when 25-75% of coffee by-products was added. Representatives of these genera are also found to have the ability to stimulate plant growth.

The obtained data contribute to the knowledge about the properties of coffee by-products (vermi)composts and indicate that such fertilizers have favorable microbiological characteristics for an agricultural application.

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GT 07 - 353 - P

EXPERIMENTAL STUDY ON THE SWELLING STABILIZATION OF A CLAY USING BIOCHAR

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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According with the literature, nearly 92,6% of soils in Spain are potentially expansive. As a result, several researchers have sought mechanisms or materials capable of reducing or eliminating the potential instability caused by this type of soils. These materials are known as swelling inhibitors or stabilisation mixtures. One of the most common lines of research in this area involves the use of pozzolanic materials, such as cement or fly ashes. However, biochar is also a material with potential interest for soil stabilisation.

The significance of this research lies in its contribution to the reduction of soil swelling using biochar as stabilisation material agent in soil mixtures. Based on a methodology that includes the measurement of swelling pressure using the Lambe apparatus, in accordance with UNE 103600:1996, this work aims to identify a low-cost method to reduce the expenses associated to unstable slopes or buildings foundations caused by the swelling behaviour of expansive soils.

This research contributes to the durability of infrastructure built on or near expansive soils. Some of these facilities are energy-related which often include expensive and sensitive components such as photovoltaic modules or li-ion batteries. The main objective of this research is to assess the possibilities involved in the lifespan extension of facilities due to the decline of the expansive behaviour of soil.

In summary, this work offers a technical contribution to the field of soil stabilization, highlighting the possible advantages of incorporating biochar into expansive soils as a sustainable and economical alternative to conventional stabilizers.

GT 07 - 371 - P

ASSESSING NUTRIENT DYNAMICS IN HYDROCHAR-AMENDED SOIL WITH RADIOGENIC $^{87}SR/^{86}SR$ ISOTOPE RATIOS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Hydrochar (HC) amendments can enhance soil health, promote microbial activity, and support plant productivity. Among their various properties, hydrochars also retain nutrient elements from the original biomass feedstock offering plants an alternative nutrient source. Understanding the interactions between these carbonaceous materials and the soil–plant system is essential for optimizing their application and environmental impact.

In this study, we employed radiogenic strontium isotope ratios ($^{87}Sr/^{86}Sr$) as a geochemical proxy for calcium (Ca)[1-2] to trace nutrient sources in a pot experiment with sunflower cultivation, conducted in the greenhouse facilities of IG-CSIC in Seville. Sr isotopes are particularly advantageous as they are not fractionated during plant uptake or translocation, making them robust tracers for assessing source contributions within the soil–plant continuum.[3-5]

Analyses of Sr-isotope compositions in soil, HC, and sunflower leaves revealed that, despite substantial differences in Sr-isotope ratios of the total Sr pools between source materials (0.70618 ± 0.00006 in soil vs. 0.71331 ± 0.00096 in HC), the Sr-isotope ratios of the plant-available Sr pools in HC (0.70849 ± 0.00001) and soil (0.70926 ± 0.00003) were more closely aligned. Correspondingly, the $^{87}Sr/^{86}Sr$ ratios in plants (range: 0.70935 - 0.70947) were indifferent from those in control treatments, regardless of fertilization or irrigation regime. These findings indicated that plant Sr uptake originated from the native soil pool (see figure).

Quantitative analysis of the plant-available Sr pools in soil and HC confirmed the minimal contribution of HC. Only 0.015 % Sr and 0.03 % Sr in the HC-3.5 and HC-6.5 treatments, respectively, were contributed by HC to the overall plant-available Sr-pool in each pot. This low incorporation explained the absence of any detectable shift in plant Sr-isotope signatures despite the isotopic contrast between HC and soil. Ca contributions from HC were similarly low - 0.055 % and 0.11 % Ca in the plant-available Ca pools of HC-3.5 and HC-6.5, respectively.

While HC provides various agronomic benefits, the impact of this specific HC as a significant Sr (and by extension Ca) source for short-term plant uptake appears negligible under the tested conditions. Nevertheless, these findings demonstrate the utility of Sr isotopes in disentangling nutrient dynamics in amended soils. However, effective source tracking requires: (i) the isotopic Sr ratios of the relevant pools must differ substantially and (ii) potential contributions to the nutrient pool should exceed 10%.

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GT 07 - 412 - P

PHOSPHORUS AVAILABILITY AND USE EFFICIENCY OF RECYCLED NUTRIENT FERTILIZERS IN CONTRASTING SOIL TYPES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Mineral fertilisers derived from non-renewable phosphate rock are widely used due to the limited availability of phosphorus (P) for plant uptake, caused by fixation and low solubility in soil, raising concerns about long-term agricultural sustainability. Recycled nutrient fertilisers (RNFs) offer a promising alternative by closing nutrient loops and supporting the transition to a circular economy. However, their agronomic efficiency depends on the recycling process, properties, and soil conditions influencing P availability. This study aimed to evaluate the availability and agronomic performance of RNFs in two soils differing in P content by assessing yield response, soil nutrient dynamics, and P use efficiency.

A pot experiment was conducted using perennial ryegrass (Lolium perenne L. cv. Sirtaky) in two Swedish soils with different P status (Kårbo (Kb): sandy, low P; Krusenberg (Kr): sandy loam, higher P). Pots (2.9 L) were filled with 2 kg of air-dried, sieved soil and amended with all main nutrients except P. In Kb, treatments included an unfertilised control (CR), a P control (P0), five TSP rates (P1–P5; 11.25–135 mg P kg^{-1}, equivalent to 25–300% of the RNF P rate), and six RNFs applied at 45 mg P kg^{-1}: centrifuge-separated digestate (CS), biochar from CS (BCS400), biothermally composted CS (CM), struvite recovered from sewage sludge (ST), and two pelletized products (PD-A, PD-E) derived primarily from digestated pig manure. In Kr, the treatments included CR, P0, CS, BCS400, ST, and PD-E. Plants were harvested at 30, 50, and 75 days. After the harvest, soil pH, ammonium and nitrate nitrogen (Nmin), and plant available P (P-AL) were analysed. Agronomic efficiency index (AEI) was calculated for Kb based on yield relative to the TSF gradient.

PD-A showed the highest AEI (117%), driven by a strong yield response in the third cut, while ST, CM, and BCS400 also demonstrated high efficiency but with more balanced P uptake during the plant growth. CS and PD-E had lower AEI (51% and 55%), reflecting limited or delayed P release. In Kb soil, P-AL remained low in all RNF treatments, but in PD-A, ST and CM likely due to efficient plant uptake, whereas CS and PD-E showed low yield and residual P in soil which may indicate lower availability of P from RNF. Significant differences in yield and P-AL were also observed for ST and BCS400 compared to P0 in Kr. Elevated Nmin in PD-A and PD-E reflected their ammonium content, while other treatments had minimal effect. PD-A and PD-E caused the strongest pH decline in both soils, potentially enhancing P solubility, whereas BCS400 maintained higher pH in Kb and was pH-neutral in Kr. These findings indicate that specific RNFs, depending on their composition and nutrient recycling approach, can be viable alternatives to mineral P fertilisers.

GT 07 - 419 - P

EFFECT OF DIGESTATE AND BIOSTIMULANT APPLICATION ON THE PROPERTIES OF MODAL CAMBISOL IN THE VYSOČINA REGION, CZECH REPUBLIC

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Given the risk of phosphate rock depletion—the primary source of phosphorus in agriculture—there is increasing interest in alternative, recyclable nutrient sources. Digestate, a by-product of anaerobic fermentation, represents a promising material for returning macronutrients and organic matter to the soil environment. This study aimed to evaluate the effect of digestate application, both alone and in combination with a foliar-applied biostimulant, on the chemical and physical properties of soil in a field experiment.

The trial was conducted in 2023 in Hodov (Třebíč District, 480 m a.s.l.) on modal Cambisol. The experimental design included three treatments: V1 – control (no digestate application); V2 – digestate at a rate of 20 $t \cdot ha^{-1}$; and V3 – digestate at 20 $t \cdot ha^{-1}$ combined with a foliar application of a biostimulant at 0.4 $l \cdot ha^{-1}$, applied using a backpack sprayer. The crop sequence included winter wheat (2023), followed by winter oilseed rape (2024).

Digestate was applied at the onset of the growing season using a hose applicator and incorporated into the soil with a disc harrow. Soil samples were collected before and after the growing season from depths of 0–0.15 m and 0.15–0.30 m. Samples were analysed for selected chemical parameters—pH/KCl, Cox, total nitrogen, P, K, Ca, Mg, humus content and quality (humic to fulvic acid ratio)—and selected physical parameters—gravimetric soil moisture, bulk density, and penetration resistance. Analytical methods included standard procedures (Mehlich III, Kjeldahl, Nelson & Sommers). Soil compaction was measured using an Eijkelkamp electronic penetrometer. Statistical analysis was performed using ANOVA and Fisher's LSD test ($p = 0.05$, StatisticaCZ12).

The results indicated that digestate application did not lead to a significant increase in penetration resistance or changes in bulk density. Conversely, treatments involving digestate—particularly in combination with the biostimulant—resulted in increased soil moisture content, improved water regime, and a shift in pH towards neutral values. A significant increase in available phosphorus and potassium was observed, while calcium levels slightly decreased but remained above high-supply thresholds (>5400 $mg \cdot kg^{-1}$). Magnesium levels increased without exceeding critical limits. The combined application of digestate and biostimulant improved humus quality (HK/FK ratio), leading to better soil structure and potentially enhanced crop yields.

In conclusion, the application of digestate—especially when combined with a biostimulant—positively influenced soil fertility, improved soil physical properties, and supported the sustainability of agricultural systems.

KEYWORDS

digestate, biostimulant, Cambisol, sustainability, circular economy

ACKNOWLEDGEMENTS

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GT 07 - 440 - P

EFFECT OF SURFACE-APPLIED COMPOST WITHOUT INCORPORATION ON SOIL PROPERTIES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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A three-year field experiment (2022–2024) was conducted in Blatnice, Czech Republic, to assess the effect of surface-applied compost without soil incorporation on soil properties. The site is classified as modal carbonate cambisol (WRB: Calcaric Cambisol), located in the MT2 climatic region (mean annual temperature 7–8 °C; annual precipitation 550–650 mm). The soil is deep, loamy, non-skeletal with a gentle slope (0–3°).

Two treatments were established: (i) untreated control and (ii) compost applied annually at 30 t.ha-1 post-harvest. The crop rotation comprised oilseed rape (2022), winter wheat (2023), and maize for grain (2024).

Soil sampling occurred before sowing and after harvest each year. Physical analyses included bulk density, total porosity, gravimetric soil moisture, maximum capillary water capacity, and minimum air capacity at depths 0–0.10 m, 0.10–0.20 m, and 0.20–0.30 m. Aggregate size distribution was assessed by dry sieving at 0–0.15 m and 0.15–0.30 m; a structure coefficient quantified the ratio of agronomically valuable to less stable aggregates.

Chemical analyses comprised pH/KCl, total nitrogen, available phosphorus, potassium, magnesium, calcium, organic carbon (Corg), total humus, and humic-to-fulvic acid ratio. Organic carbon was measured by wet oxidation; humus was calculated using the Welte coefficient. Biological properties were evaluated through microbial biomass carbon and potential mineralisable nitrogen.

Surface-applied compost without incorporation significantly reduced bulk density in the upper soil layer and enhanced soil moisture retention at all depths. Structural stability improved, with higher proportions of stable aggregates. Treated soils exhibited increased pH/KCl, enhanced macronutrient availability, and a trend towards higher organic carbon, though not statistically significant. Microbial biomass was unaffected, while potential nitrogen mineralisation increased.

Crop yields showed no significant changes; however, winter wheat grain quality improved in nitrogen and gluten content following compost application. The compost mulch reduced evaporative losses and soil erosion risk. Surface application without incorporation decreased machinery requirements, yielding 20–30% operational cost savings.

These results demonstrate that surface application of compost without soil incorporation is a viable strategy in temperate arable systems. It maintains soil function, supports soil conservation, and aligns with reduced tillage principles and efficient resource use.

KEYWORDS

surface-applied compost, no incorporation, soil properties, soil moisture, soil compaction, mineralisable nitrogen

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GT 07 - 449 - P

IMPACT OF ORGANIC COMPOSITES ON THE NITROGEN-SUPPLYING POTENTIAL OF BROWN FOREST SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Own-developed organic based soil conditioner composites were tested in a four-month-long incubation experiment. The composite has consisted of fermented chicken manure as a base material, with bentonite and a superabsorbent polymer as additives.

This study aimed to determine their effects on soil N mineralization, and the changes in the amount of soil mineralized nitrogen forms, cumulative mineralized nitrogen (Nmin), and C/N ratio in a sandy soil (Lamellic Arenosol) at two different soil water holding capacity (SWHC) levels (40 w/w% and 60 w/w%) and layers. Potentially mineralized nitrogen (PMN), net mineralization (NMR), and nitrification rates (NNR) were also calculated to study the effectiveness of treatments. Soil NH4-N decreased by 50-70% while NO3-N increased by 150-200% in the treated soil, so the nitrate/ammonium ratio was changed from 1/3 to 2/1 during the incubation. Nmin gradually increased and was described by a linear tendency (R≥0.99) for both soil layers and SWHC levels. Composite treatments increased significantly the potentially mineralized nitrogen, and net mineralization rates by 2-4 times and nitrification rates by 40-240% compared to the control. Applied composites enhanced the mineralized proportion of total nitrogen content by 2-6%. It was found that the composites were more effective at lower SWHC level and in their application layer than chicken manure alone. Overall, the developed organic-based composites can cope with changing soil circumstances that could help to mitigate the negative effects of climatic anomalies, especially in arid areas with limited water resources by improving soil nutrient supply, thus contributing to sustainable nutrient management.

Soil conditioner composites were tested in an incubation experiment to estimate their effects on soil N mineralization.

Treatments affected the ratio of mineralized N forms and caused a higher mineralization rate.

Composite treatments increased significantly the PMN, NMR, and NNR values compared to the control and chicken manure alone.

Composites could help mitigate the negative effects of climatic anomalies, especially in arid areas and with poor nutrient supply by improving soil N availability.

ACKNOWLEDGEMENTS

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GT 07 - 463 - P

CAN VERMICOMPOST AND BOKASHI BE ASSETS FOR SHORT-TERM SOIL REGENERATION IN AGRICULTURE?

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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While soil organic matter content declines with the intensification of agricultural practices and the use of synthetic fertilizers, biowastes from the food industry represent a resource to be valorised. Bokashi and vermicompost of biowaste are low-cost transformation processes that have been little studied. Bokashi is the product of controlled lactic fermentation under anaerobic conditions and renders digestible for earthworms some difficult wastes, such as citrus fruits. Our study investigated the short-term effect of the two amendments on soil physico-chemical and biological properties when applied in the field.

A field trial was initiated in conventional farming in April 2023 with randomized blocks for five treatments: control without organic amendment, two bokashi, and two vermicomposts, from either spruce or beech chips. All products were brought to a 2 tons per hectare equivalent organic C before each cultural cycle. Carbon and nitrogen mineralization kinetics and the Organic Matter Stability Index were measured under laboratory conditions. Soil analyses (organic matter, organic carbon, total nitrogen, C/N, P, K, Ca, Mg, trace elements, CEC) were carried out once a year. Earthworms were sampled, identified, and weighed every six months.

Product analyses showed that vermicomposts have higher mineral matter content and lower C/N values than bokashi of the same entry product (spruce or beech). All products have low nitrogen mineralization over 90 days, but values were higher for vermicomposts than for bokashi. One year after spreading, results of soil physico-chemical properties showed no difference among treatments except for magnesium contents, which were significantly higher in beech-based bokashi and vermicompost than in spruce-based vermicompost. Both spruce and beech bokashi significantly increased earthworm total abundance and biomass compared with the control treatment after 18 months (by 110% and 104% respectively for total abundance and 72% and 91% respectively for total biomass). Compared to the control, abundance of endogeic worms was significantly higher in spruce bokashi after six months (+115%), in beech bokashi after one year (+164%), and in both bokashi after 18 months (+139% for spruce and + 98% for beech). Total abundance of anecic worms was also significantly higher in beech bokashi after 12 and 18 months (+140% and +70% respectively). The earthworm population in vermicompost treatments did not differ from the control.

Product characterization suggests that the studied bokashi and vermicomposts are close to green waste compost (thus amending products), with a fertilizing potential slightly more advanced for vermicomposts. Although bokashi and vermicomposts have no significant effect on soil physico-chemical properties one year after application, our study showed that spruce and beech-based bokashi in conventional farming led to increases of total earthworm abundance and biomass after only six and 12 months, respectively.

GT 07 - 469 - P

CAN BIOCHAR HELP TO ALLEVIATE MACHINERY-INDUCED SOIL COMPACTION DUE TO AGRICULTURAL MANAGEMENT? A FIELD STUDY IN A VINEYARD.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil compaction resulting from mechanized agricultural practices is a significant concern, as frequent machinery use deteriorates soil structure, reduces porosity, and ultimately impairs crop productivity. Among the various strategies to enhance soil resilience to machinery-induced compaction, the use of biochar has not yet been validated under real field conditions, despite laboratory studies suggesting its potential to reduce soil compactability.

With this aim, we monitored a soil in a vineyard in Tuscany where biochar was applied at single (16 t ha^{-1}) and double (32 t ha^{-1}) dose, against a non-biochar amended plot, across plots with flat and sloped terrain. Soil compaction was induced by means of 20 passes of a wheeled orchard tractor. Soil bulk density (BD) was measured just before and immediately after the initial tractor passes, as well as one year later, during which an additional 26 machine passes occurred as part of the vineyard's routine agronomic management. Results showed that the repeated machine passage led to a significant increase in BD (up to 12.8%) throughout all the treatments, but that biochar application significantly limited soil compaction, independently from the application dose. However, after one year in which the soil underwent further compaction, bulk density continued to rise across all soil treatments (up to 20.2%), with the steepest increase observed on the sloped terrain. At this stage, the mitigating effect of biochar on soil compaction was no longer apparent.

Our findings from this field study suggest that biochar may offer short-term benefits in mitigating soil compaction; however, further research is needed to develop a more comprehensive understanding of its role in counteracting compaction in a longer term.

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GT 07 - 489 - P

ORGANIC AND MINERAL AMENDMENTS BOOST THE PLANT- AND MICROBIAL-DERIVED ORGANIC MATTER ACCRUAL IN A SALINE-ALKALI SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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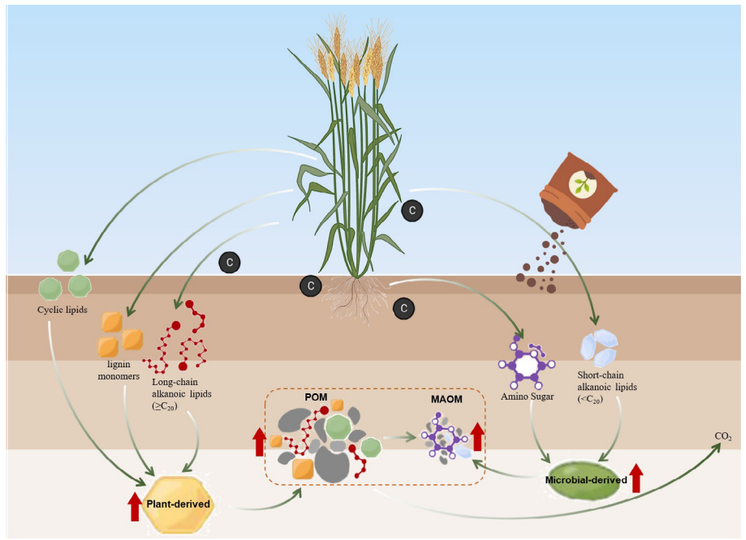
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Purpose: Soil amendments has been recognized as effective strategies to enhance soil organic matter (SOM) sequestration and soil health. Yet, the extent to which the organic and mineral amendments influence SOM biochemistry remains elusive. Using lignin phenols, amino sugars and glomalin-related soil proteins (GRSP) as biomarkers - we quantified SOM characteristics from a 3-yr trial with different soil amendments in a saline-alkali soil of Yellow River Delta, North China.

Methods: The experimental designs included six treatments: non-amended control (CK), wollastonite powder (Si), vermicompost (EM), bio-organic fertilizer (BOM), a combined Si and EM (EM+Si), and Si and BOM (BOM+Si). Soil samples were collected from 0-20 cm depth, and the SOM properties (i.e., biomolecules, lability and sources) were characterized. Also, we analyzed soil physicochemical properties, salinity parameters, and water-stable aggregates.

Results: The results showed that applied BOM and particularly combined BOM+Si reduced soil salinity, and improved soil structure, and the overall SOM quantity. Compared to CK, BOM and BOM+Si significantly increased the macroaggregates fractions (>0.25 mm) by 50.6-57.1%, and mean weight diameter by 60.7-68.1%, likely due to the increased organic glue agents (e.g., EPS, extracellular protein, soil organic C) and anion (e.g., Ca2+, Mg2+). BOM and BOM+Si amendments had 66.4-77.6% higher lignin phenols, and lower the ratio of syringic acid to syringaldehyde by 44.2-63.3% relative to CK. Compared to CK, EM+Si amendments had 48.8% higher lignin phenols, and lower the ratio of syringic acid to syringaldehyde by 33.4%. On the other hand, BOM and BOM+Si increased bacterial, fungal and total microbial necromass carbon by 52.7-61.6%, 165.8-199.4% and 93.6-112.0% relative to CK. Compared to CK, EM+Si increased bacterial, fungal and total microbial necromass carbon by 22.6%, 102.1% and 50.6%. Both BOM and BOM+Si increased easily extractable GRSP (E-GRSP) and total extractable GRSP (T-GRSP) by 20.0-27.7% and 21.2-26.7% compared with CK. Besides, EM+Si had 7.1% higher E-GRSP, and higher 9.9% T-GRSP relative to CK.

Conclusion: We concluded that organic amendment, particular combined with minerals could increase the plant- and microbial-derived organic matter accumulation and could be recommend as effective strategies to reduce soil salinity, and improve soil health and crop productivity.



GT 07 - 513 - P

COMPARING THE PERFORMANCE OF BIOCHAR CO-COMPOST WITH THAT OF COMPOST IN THE FORMULATION OF TECHNOSOLS FOR THE RESTORATION OF DEGRADED AREAS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The restoration of degraded ecosystems following mining activities using artificial soils, known as Technosols, may provide an opportunity to enhance soil carbon storage and generate carbon credits, while supporting ecosystem services. In particular, the use of organic amendments derived from agri-food organic waste— processed through pyrolysis, composting, or digestion— and combined with locally available mineral substrates, presents a valuable opportunity to repurpose organic waste and offers a promising solution for restoring these systems.

To this regard, our study aims at assessing the performance of biochar-enriched co-composts compared to standard composts in Technosol formulations, including their impact on soil physicochemical properties and vegetation development. For this purpose, three experimental sites representing different climates and lithologies were selected. Technosols were formulated using various combinations of mineral substrates and organic amendments, including compost of the organic fraction of municipal solid waste (OFMSW), compost of the anaerobic digestion of the OFMSW, their respective biochar co-composts, and a field-applied mixture of compost plus biochar. All sites were sown with a grass-legume seed mixture.

Results showed that, as expected, all amended Technosols significantly increased soil organic carbon and nutrient availability relative to unamended controls. Moreover, biochar co-composts, in addition to contribute to a more durable soil carbon, increase microbial biomass compared with Technosols amended with compost alone. All amended Technosols substantially improved vegetation cover, with biochar-containing treatments showing greater plant height compared to only compost treatments.

In conclusion, the incorporation of biochar—particularly as biochar co-composts—provided clear additional benefits to soil restoration across diverse degraded mine sites. These findings underscore the added value of biochar in Technosols-based ecosystem restoration strategies, particularly for enhancing soil function and long-term carbon storage. Future monitoring will determine their long-term effectiveness.



Overview of the tratment plots at the restoration of la Falconera mining site.



GT 07 - 517 - P

THE EFFECT OF SEWAGE SLUDGE AND COMPOSTED SLUDGE ON THE SOIL PORE SYSTEM STUDIED USING THE X-RAY COMPUTED TOMOGRAPHY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 05. SOIL HYDROLOGY & EROSION

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Sewage sludge from wastewater treatment plants (WWTPs) and composted sludge are commonly used as soil amendments due to their high organic matter and nutrient content. However, their impact on soil physical properties, particularly soil porosity and pore connectivity, is critical because: Soil pores influence water retention, aeration, root penetration, and microbial activity. Changes in pore structure can affect plant growth, carbon sequestration, and greenhouse gas emissions. It is assumed that sewage sludge can increase total porosity but may clog macropores due to finer particles. Composted sludge often enhances soil structure more uniformly, increasing both macro- and mesoporosity. Compost improves pore connectivity better than raw sludge due to stabilized organic matter. Improvements in pore structure can result in better water regime.

To confirm these hypotheses, the effect of digested sewage sludge taken from the WWTP and composted sludge on soil porous system was studied at three locations: Častrov (Cambisol), Hněvčeves (Luvisol) and Humpolec (Cambisol). Plots with added biosolids were compared to control plots. Two types of undisturbed soil samples (volume of 450 cm3 and 100 cm3) were collected from the surface horizon 3 times over the vegetation period. The 450-cm3 soil samples were taken at a depth of 1-13 cm using plastic columns with a diameter of 7 cm and a height of 12 cm. These samples were used to analyze soil-pore structure and image-porosity using X-ray computed tomography (Nikon XT H 225ST). The 100-cm3 were used to measure the total porosity and soil hydraulic properties using standard methods.

The total porosities and image porosities decreased over time in all cases. The highest total porosities were usually found for soil with composted sludge followed by control soil and soil with sewage sludge. However, ambiguous results were observed when comparing image porosities from different scenarios at different locations. For example, while image porosities for Luvisol followed trends of the total porosities, different trends in image porosities were observed for Cambisols for each sampling day.

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GT 07 - 522 - P

TAILORING CALCIUM AMENDMENT STRATEGIES FOR ALFALFA: LONG-TERM YIELD RESPONSES TO RAW, BURNED, AND SULFATE-BASED INPUTS ACROSS CONTRASTING SOILS AND STAND TYPES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Alfalfa (Medicago sativa L.) is a high-value forage crop with strong ecological benefits but is particularly sensitive to soil acidity and nutrient deficiencies. While current fertilization guidelines in regions like Québec favor raw limestone ($CaCO_3$) exclusively, other calcium amendments, including burned limes (CaO, $Ca(OH)_2$) and sulfate-based materials, are commonly used elsewhere and may offer agronomic advantages. However, their effectiveness may vary with soil texture, root system maturity, and application method. This study evaluated the impact of nine calcium-based amendments: raw lime, burned lime, and sulfate-based non-liming materials, applied at a uniform spring rate (3 Mg ha^{-1} $CaCO_3$-equivalent or 1.2 Mg ha^{-1} Ca for anhydrite) on two alfalfa stands (establishment vs. maintenance) and two contrasting soil textures in Québec, Canada. Agronomic performance was monitored over four consecutive growing seasons.

Results revealed contrasting responses: newly seeded alfalfa on clay soil showed no yield response to amendments, while the mature stand on sandy soil exhibited strong and lasting responses. Sulfate-based treatments (CHAC, anhydrite, and lime-anhydrite) increased yields by up to 10,000 kg ha^{-1} over the control in favorable years, with gains persisting across four seasons after a single application. Mixed lime treatments ($CaCO_3$ + CaO and/or $Ca(OH)_2$) also outperformed raw lime without causing phytotoxicity.

These findings highlight the need for stand- and soil-specific calcium amendment strategies. Sulfate-based and blended formulations applied every four years may sustainably enhance productivity in mature alfalfa systems on coarse soils. Exclusive reliance on raw lime may overlook the agronomic potential of alternative materials proven to be both effective and safe.

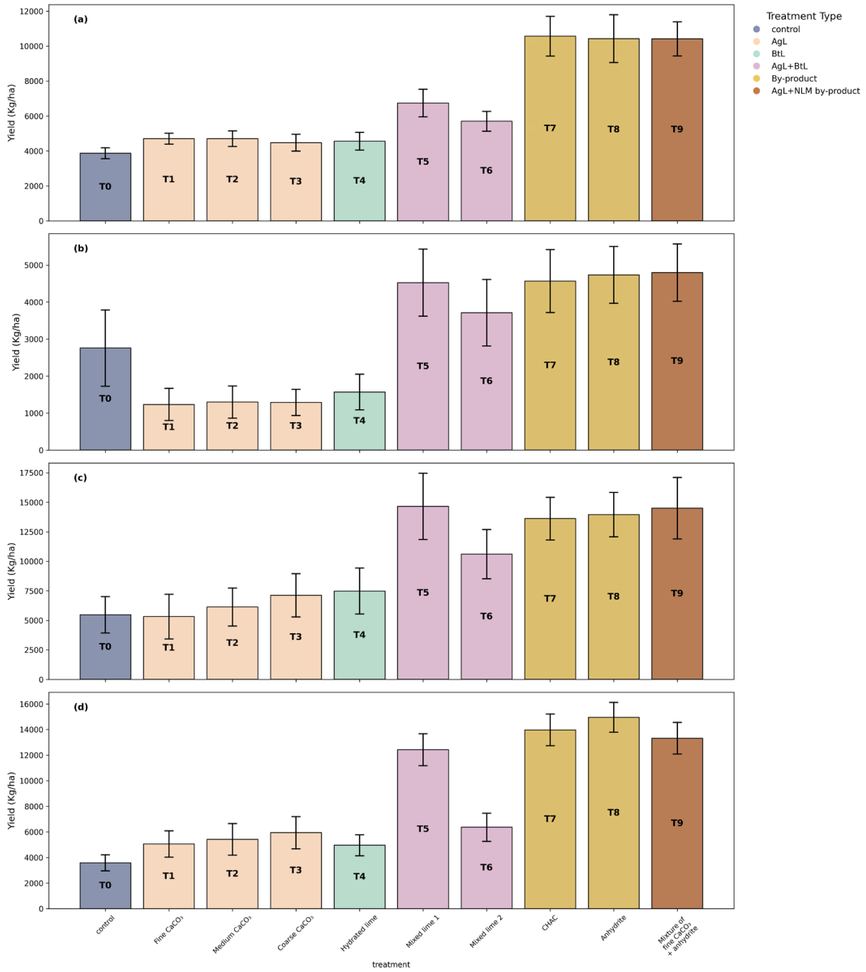
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Annual alfalfa biomass yield at Site 2 in response to spring-applied calcium amendments of different types — raw, burned, sulfate-based, and blended forms — with yield measured over four seasons: (a) 2020, (b) 2021, (c) 2022, (d) 2023.

GT 07 - 523 - P

HOW BIOSOLIDS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT AFFECT SOIL PROPERTIES AND PROCESSES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 05. SOIL HYDROLOGY & EROSION

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The aim of this study was to describe the effect of digested or composted sewage sludge on soil moisture and temperature, and soil hydraulic properties. The effect on plant quality and CO2 emission from the soil was also evaluated. The experiment was carried out on two sites with different soil types, Haplic Luvisol in Hněvčeves and Haplic Cambisol in Humpolec (Czech Republic). Either digested or composted sludge was applied to both fields in 2022 before sowing maize (Zea mays L.). One plot on both sites was managed in a standard way (control). Soil moisture and temperature were continuously measured using TMS4 sensors throughout the growing season. Soil sampling and field measurements were conducted before biosolids application and next three times during plant growth. The disturbed soil samples were used to measure active and exchange soil reactions, oxidizable carbon content, soil salinity, and stability of soil aggregates. Two types of undisturbed soil samples were also taken. Undisturbed 100-cm3 soil samples were used to measure bulk density, total porosity and soil hydraulic properties. Undisturbed 450-cm3 soil samples were used for pore system analysis using Nikon XT H 225ST X-ray computed tomography. Furthermore, unsaturated hydraulic conductivities for a pressure head of -2 cm were measured directly in the field using mini disk tension infiltrometers with a disk radius of 2.22 cm. The measurements were carried out both in the rows between the corn plants and between two corn rows. In addition, CO2 emissions from the soil was measured using the LCi-SD portable photosynthesis system with a chamber for measuring soil respiration. The same device was also used to measure transpiration and photosynthesis of corn leaves. The chlorophyll content of the leaves was measured using the CCM 200 plus device. Plant heights for individual variants and plant biomass were measured at the end of the experiment. The results showed that digested sewage sludge and composted sewage sludge mostly affected all soil and plant properties. Both compost and sludge increased the soil water retention capacity. The unsaturated hydraulic conductivities measured for the different variants in Hněvčeves did not differ. On the other hand, in Humpolec, considerably higher unsaturated hydraulic conductivities were found for soil with compost than for other two variants. On both sites, higher unsaturated hydraulic conductivity was measured in the rows (i.e. between plants) than between the rows. The highest CO2 emissions from the soil were measured from soils with compost followed by soils with sludge and control. Both biosolids also positively affected all plant parameters.

ACKNOWLEDGEMENTS

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GT 07 - 539 - P

EFFECT OF BIOCHAR APPLICATION ON THE HEALTH OF MEDITERRANEAN SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Agricultural soils are often subject to management practices that can compromise their health. In extreme cases, these impacts may lead to crop abandonment. Although abandoned soils can gradually recover their quality, this process may take decades. Soil organic carbon plays a key role in soil quality and health, influencing a wide range of physical, chemical, and biological properties. Enhancing soil quality directly supports plant growth and development.

Biochar, a carbon-rich material produced by pyrolysis of organic residues, has been shown to improve soil water retention, structure, and cation exchange capacity, among other benefits. These improvements may accelerate the recovery of soil functionality and promote plant development. However, biochar's effects can vary depending on soil type and application rate.

In this study, we evaluated the impact of two biochar doses on soil health indicators and lettuce (Lactuca sativa) growth in three Mediterranean soils with contrasting characteristics. The soils, located in the province of Granada (southern Spain), were selected as part of the European project FENIX (New Life for Biowaste as a Sustainable Soil Improver). They have different land-use histories: organically managed olive groves (SpO), avocado orchards (SpA), and abandoned cereal fields (SpC).

Approximately 4 kg of each soil type were incubated for three months with biochar at 2.5% and 5% v/v, alongside untreated controls. Soil moisture was maintained at field capacity. Enzyme activities (β-glucosidase, dehydrogenase, acid phosphatase, and urease) were measured at the beginning and end of the incubation. Additional baseline measurements included pH, electrical conductivity, exchangeable bases, cation exchange capacity, and microbial, soluble, and total organic carbon.

Results showed significant improvements in most soil health parameters with biochar addition, particularly in the SpO soil, followed by SpC and SpA. Improvements included enhanced soil structure and biochemical activity, suggesting that biochar efficacy depends on intrinsic soil properties.

Subsequently, lettuce was planted in 0.5 L pots (five replicates per treatment and control) and grown for one month under greenhouse conditions with controlled temperature and field-moisture levels. Leaf number, plant height, and leaf area were recorded weekly. Notably, from the first week, lettuce growth was greater in SpO and SpC soils compared to SpA.

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GT 07 - 541 - P

PHOSPHORUS DILUTION CURVE AND PHOSPHORUS NUTRITION INDEX AS TOOLS TO EVALUATE THE PHOSPHATE FERTILIZER POTENTIAL OF BBFS IN DURUM WHEAT UNDER DROUGHT CONDITIONS IN MEDITERRANEAN CLIMATE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Phosphorus (P) is an essential nutrient for crop growth, but its future availability is threatened by reliance on non-renewable mineral sources, whose extraction and distribution pose economic and geopolitical risks. In response to this challenge, bio-based fertilizers (BBFs)— produced from organic, plant, animal, or industrial waste— have gained attention as sustainable solutions within a circular economy framework. However, their efficient use still presents challenges due to the high variability in their chemical composition, solubility, and behavior in soils. Most of effort evaluating BBFs have been assessed in controlled climate conditions. Performance of BBFs may be modified by extreme climate conditions, which are expected to be frequent under the climate change prospectives. Therefore, agronomic tools capable of evaluating their effectiveness in an integrated, rapid, and reliable manner are essential. This study assessed the performance of 11 BBFs in durum wheat (Triticum durum) cultivation under rainfed conditions in Seville over two consecutive growing seasons (2020–2021 and 2021–2022), both characterized by low rainfall and high temperatures during critical stages of the crop cycle. BBFs were applied at a rate of 20 kg P ha-1. Several agronomic indicators were used for evaluation: The Phosphorus Nutrition Index (PNI), based on a critical dilution curve relating plant P concentration to dry biomass; and other classic agronomic indexes such as Phosphorus Use Efficiency (PUtE) or the Phosphorus Harvest Index (PHI). The resulting dilution curve showed a more negative exponent than those described in the literature (-0.65), reflecting low water availability, which reduced phosphorus uptake in later stages of crop development. Most BBFs achieved adequate nutrition levels (PNI ≥ 1), though differences between products were observed. BBFs based on phytic acid and struvite stood out for their high PNI at anthesis (up to 39% higher than those with hydroxyapatite), although this advantage diminished by the end of the cycle. Some organic BBFs promoted high P uptake but negatively affected agronomic efficiency by inducing excessive vegetative growth and delaying maturity. The PNI proved to be a valuable tool for evaluating BBFs, especially when complemented with other physiological and yield-related indicators.

KEYWORDS

Bio-based fertilizers (BBFs), Phosphorus, Phosphorus dilution curve, Phosphorus nutrition index, drought.

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GT 07 - 546 - P

IMPACTS OF FOOD WASTE COMPOST APPLICATION RATE ON SOIL ORGANIC CARBON, NITROGEN USE EFFICIENCY, AND YIELD OF CHINESE CABBAGE(BRASSICA RAPA L.)

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The sustainable recycling of food waste has emerged as an environmentally friendly alternative to conventional disposal methods, offering significant potential to reduce greenhouse gas (GHG) emissions and enhance soil fertility. This study examined the effects of varying application rates of food waste compost (FWC) on soil chemical properties, soil organic carbon (SOC) stocks, the growth and yield of Chinese cabbage (Brassica rapa L.), and nitrogen use efficiency (NUE) over three consecutive cropping seasons. Field experiments were conducted using five treatments: no fertilization (NF), inorganic fertilization (NPK), and NPK combined with one (FWC1), two (FWC2), or three times (FWC3) the standard FWC rate. Moderate application (FWC2) significantly improved crop yield and SOC in the first season. However, continuous excessive applications (FWC3) led to increased soil salinity (electrical conductivity and sodium content), decreased NUE, and suppressed plant growth and yield in subsequent seasons. While optimal FWC application enhanced SOC accumulation, excessive use caused a decline in SOC due to sodium-induced degradation of soil structure and microbial activity. These findings underscore the importance of optimizing FWC application rates to promote soil health, improve carbon sequestration, and maintain crop productivity while minimizing potential environmental risks. Further research should explore the long-term impacts of FWC on GHG emissions and soil microbial communities.

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GT 07 - 547 - P

LIME AND GYPSUM APPLICATION TO LOW ACIDITY SOIL: CHANGES IN SOIL CHEMICAL PROPERTIES AND SPRING BARLEY YIELD

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Soil acidification is a critical factor contributing to soil degradation. In Lithuania, acidic soils currently comprise approximately 21.8% of total agricultural land, and this area is increasing by about 3.8% every 10–15 years, reflecting an ongoing acidification trend. This underscores the necessity for continuous soil neutralization using calcium-rich amendments. The present study aims to evaluate the effects of calcareous materials—limestone ($CaCO_3$) and gypsum ($CaSO_4 \cdot 2H_2O$)—on soil chemical properties and spring barley productivity.

A field experiment was conducted at the Vėžaičiai branch of the Lithuanian Research Centre for Agriculture and Forestry. The experimental design included four treatments: (1) control (no amendment), (2) limestone at 4.0 t ha^{-1}, (3) gypsum at 4.0 t ha^{-1}, and (4) a combination of limestone and gypsum, each at 2.0 t ha^{-1}. Calcareous amendments were incorporated into the 0–10 cm soil layer (May 3, 2025). Two weeks later, a compound NPK (10-26-26) fertilizer was applied at 250 kg ha^{-1}, and spring barley cultivar ‘Laureate’ was sown.

To assess treatment effects on soil chemical parameters—pH (KCl), mobile Al, and exchangeable Ca and Mg—soil samples were collected post-harvest (August 26, 2025) from four depth intervals: 0–10 cm, 10–20 cm, 20–30 cm, and 30–60 cm. Standardized analytical methods were employed. Spring barley biometric data were collected at the BBCH 87 growth stage from two 0.25 m^2 replicates per plot, evaluating productive/unproductive stem counts, ear length, grain number per ear, 1000-grain weight, and grain yield (t ha^{-1} at 14% moisture and 100% cleanliness). The experiment lasted four months.

Limestone, gypsum, and their combination significantly increased soil pH in the 0–10 cm layer. Compared to the control, pH (KCl) increased by 21% with limestone, 4% with gypsum, and 13% with combined treatment. At 10–20 cm depth, only limestone led to a notable pH increase and a significant reduction in mobile Al content. None of the treatments significantly affected mobile Al levels in deeper layers (20–60 cm) within the short study period. Exchangeable Ca and Mg levels were significantly elevated in the topsoil (0–10 cm) under all treatments. At 10–20 cm depth, only limestone and the limestone-gypsum mixture showed a trend toward increased Ca and Mg. Compared to the control, exchangeable Ca increased by 1.9 times with limestone and 1.4 times with the combined treatment. Exchangeable Mg increased by 1.4 and 1.2 times, respectively. Productivity indicators of spring barley improved under all calcifying treatments. Grain yield increased by 5–7%, attributed to a higher number of productive stems (2–5%) and greater grain number per ear (3–6%).

These findings indicate that short-term application of calcium-containing amendments, particularly limestone, can improve topsoil chemical properties and enhance spring barley productivity under acidic soil conditions.



GT 07 - 548 - P

NUTRIENT COMPOSITION OF RICE STRAW, COMPOST, AND BIOCHAR: IMPLICATIONS FOR SUSTAINABLE SOIL FERTILITY MANAGEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Rice straw, a major agricultural residue, poses a disposal challenge in many rice-producing regions. Transforming this biomass into value-added products such as compost and biochar offers a sustainable solution to waste management and soil fertility enhancement. This study aimed to compare the chemical properties—specifically pH, electrical conductivity (EC), and macronutrient content (nitrogen, phosphorus, potassium)—of raw rice straw (RS), rice straw compost (RSC), and rice straw biochar (RSB).

Rice straw was composted for 60 days under controlled aerobic conditions and separately pyrolyzed at 500°C to produce biochar. The resulting materials were analyzed for pH, EC, and concentrations of nitrogen (N), phosphorus (P), and potassium (K). The pH values increased across treatments from RS (7.47) to RSC (8.19) and RSB (9.42), with RSB exhibiting the highest alkalinity, suggesting its potential use in ameliorating acidic soils. EC was highest in RSC (4.25 dS m^{-1}), indicating a higher soluble salt content due to mineralization during composting, while RSB had the lowest EC (1.89 dS m^{-1}). Nutrient analysis showed that RSC contained the highest nitrogen (6.73 g kg^{-1}) and potassium (25.43 g kg^{-1}), making it a potent organic fertilizer. RSB, although lower in nitrogen (4.00 g kg^{-1}), retained a high phosphorus content (2.53 g kg^{-1}), likely due to the concentration effect during pyrolysis.

These findings demonstrate that both composting and pyrolysis of rice straw significantly alter its chemical characteristics, enhancing its agronomic value. Compost is more suitable for immediate nutrient supply, while biochar offers long-term soil conditioning benefits. Integrating both amendments into soil management practices could improve soil health and reduce dependence on synthetic fertilizers, contributing to more sustainable agricultural systems.

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GT 07 - 559 - P

IMPACT OF THE CO-OCCURRENCE OF THE ANTIBIOTIC SULFAMETHOXAZOLE AND A HOLM OAK-DERIVED BIOCHAR ON THE PERSISTENCE OF THE HERBICIDES FLUOMETURON AND MESOTRIONE IN AN AGRICULTURAL SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The addition of organic amendments to agricultural soils to enhance soil quality may alter the natural attenuation of pesticides present in them. Livestock manure, for instance, commonly used as a fertilizer, often contains residual antibiotics not metabolized by the animals that can affect the soil microbiome. Similarly, biochar, a carbon-rich product derived from the pyrolysis of biomass under limited oxygen conditions, has been increasingly applied as a soil amendment due to its capacity to retain nutrients, improve soil structure, and increase organic matter content. Despite the benefits that these amendments provide to agricultural soils, they may influence the environmental fate of the pesticides present in them, which has not been thoroughly studied. Therefore, the aim of this work was to evaluate the effect of the co-occurrence of the antibiotic sulfamethoxazole (SMX) and holm oak-derived biochar (BC) amendment on the persistence of two herbicides, fluometuron and mesotrione, in a Mediterranean agricultural soil from southwestern Spain. The research involved controlled incubation experiments to assess herbicide persistence in soil with different treatments (unamended, amended with BC, with and without SMX). Additionally, dehydrogenase activity was analyzed in the incubated soil as an indicator of microbial activity.

The results indicated that SMX slightly increased the persistence of fluometuron in soil, likely due to the its inhibitory effect on microbial communities. In contrast, BC amendment significantly reduced herbicide persistence, which could be attributed to the introduction of exogenous microorganisms or the stimulation of native microbial growth due to the improvement of soil properties (pH, aeration, moisture, and organic matter). When both SMX and BC were present, degradation of fluometuron was even more pronounced, indicating that the impact of BC on herbicide persistence outweighed that of the antibiotic. In the case of mesotrione, the presence of both SMX and BC in the soil significantly decreased the degradation rate of the herbicide. The dissipation results were consistent with the pattern of dehydrogenase activity: Soil > Soil + BC > Soil + BC (SMX) > Soil (SMX), suggesting that microbial degradation plays a substantial role in mesotrione breakdown.

These findings highlight the need to assess pesticide persistence in the presence of organic residues before their implementation as soil amendments, since they could lead to an unpredictable fate of these agrochemicals. Therefore, a reduction in pesticide persistence could compromise their effectiveness, whereas, an increase in persistence could result in soil contamination due to agrochemical accumulation.

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GT 07 - 608 - P

EFFECT OF FEEDSTOCK AND PYROLYSIS TEMPERATURE ON THE QUALITY OF CHROMOPHORIC WATER EXTRACTABLE ORGANIC MATTER OF BIOCHAR-SOIL MIXTURES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The use of biochar as a soil amendment has gained popularity in the last decade due to its potential to improve some soil properties related to fertility, and because it has been acknowledge as a valid method to increase soil carbon content, helping remove greenhouse gases from the atmosphere. However, the impact of biochar addition on soil organic matter composition depends on biochar characteristics, which are related to the type of feedstock and the pyrolysis temperature. In addition, biochar effects can be influenced by soil properties. Despite the extensive efforts to understand biochar-soil interactions, little is known about the impact of biochar additions on soil water-extractable organic matter content and quality, which is the most mobile organic fraction in the soil and highly relevant from the environmental point of view. Thus, the objective of this work was to evaluate the effect of several biochars on the quality of soil water-extractable organic matter in two different soils.

Biochars were produced at two temperatures (300 and 600ºC), from four feedstocks: beach-cast seaweed, poultry manure, vine pruning and broom (Cytisus scoparius) residues. These biochars were mixed with two soils (Cambic and Humic Umbrisols) and subjected to laboratory incubation experiments. After 70 days, water extracts of the mixtures were prepared, and their carbon content and optical properties were determined. These included UV-Vis absorbance and fluorescence spectroscopies. Fluorescence excitation-emission matrices were subjected to PARAFAC analysis, and differences in water extractable organic matter quality were described in terms of PARAFAC component proportions.

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GT 07 - 643 - P

BIOCHAR APPLICATION IN BIODIVERSE PASTURES: A STUDY ON CHANGING GHG EMISSIONS IN INTERACTIONS WITH SOIL TEMPERATURE AND MOISTURE FOR TWO YEARS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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This study investigates the effects of biochar application and rainfall reduction on greenhouse gas (GHG) emissions, soil temperature, and moisture in biodiverse pastures over a two-year field experiment in central Portugal. Biochar was applied at 3% (w/w) to a hard-setting sandy loam soil, and a 50% rainfall reduction was simulated using rainout shelters, reflecting future climate scenarios. Four treatments (i) no biochar 100% rainfall; ii) no biochar 50% rainfall; iii) biochar 100% rainfall; iv) biochar 50% rainfall) were monitored. GHG fluxes (CO_2, CH_4-C, and N_2O) were measured monthly (34 times), while soil temperature and moisture were continuously recorded at various depths. Results show that biochar slightly reduced the daily air and soil temperature ranges and improved moisture retention, especially under reduced rainfall. GHG fluxes were seasonally dynamic, with the most significant emissions during the spring growth peak in April. Biochar reduced CO_2 and N_2O emissions, especially under natural rainfall, with up to 26% and 93.9% reductions on specific sampling days, respectively. CH_4-C fluxes remained low, with minor variations between treatments. During GHG sampling hours, biochar-treated plots showed more stable and higher soil moisture, particularly at 15 and 25 cm, which likely influenced emission dynamics. These findings highlight the potential of biochar to moderate soil microclimate and mitigate GHG emissions under current and projected climate conditions in Mediterranean pastures.

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GT 07 - 646 - P

AGRONOMIC VALUE OF LIME MATERIALS IN THE 21ST CENTURY ON SOIL PROPERTIES AND CROP PRODUCTIVITY - META ANALYSIS.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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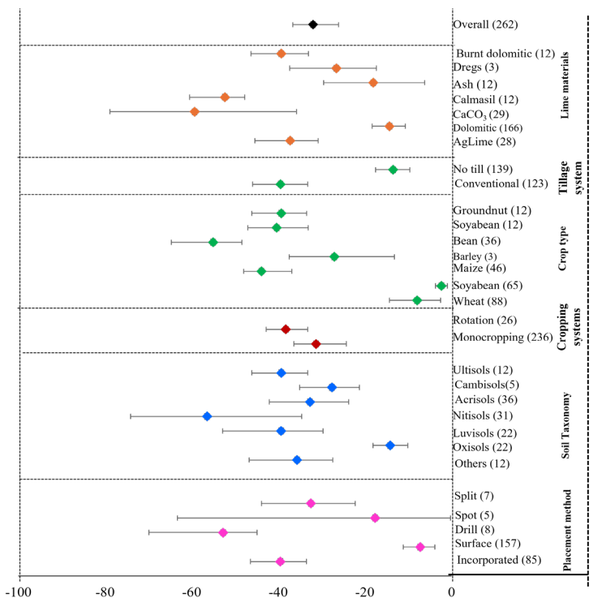
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Healthy soils are critical for global food production and human well-being, while soil acidity reduces base cations required for plant growth and may produce phytotoxic concentrations of soluble aluminum. Liming acidic soil is generally promoted as an effective management practice to increase soil pH and base cation concentrations to ameliorate such toxicities. Through a review of global literature using data published from field experiments on liming and non-liming materials, this paper explores their agronomic value on various soil physicochemical properties and crop yields as influenced by different agronomic practices. The results show that overall positive effect size of 17.54% was recorded for lime materials and their placement methods, tillage systems, crop types, cropping systems, and soil texture in response to soil pH. Dolomitic lime, CaCO3, and agricultural lime had positive effect sizes of 14.12%, 15.19%, and 21.16%, respectively. Different lime materials had effect sizes that varied considerably from -17.59% to 20.9% on soil available P. Calmasil, CaCO3, burnt dolomitic, aglime, dregs, ash, and dolomitic all exhibited negative effects on H + Al, with mean effects of -52.35%, -59.32%, -39.32%, -37.24%, -26.58%, -18.07%, and -14.3%, correspondingly. Of 14 lime materials identified, pelletized lime, aglime, burnt dolomitic, and CaO demonstrated negative mean effects of -59.86%, -11%, -0.74%, and -0.57%, respectively. The most distinct variables driving changes were lime type, soil type, tillage system, crop systems, and the placement method on different crops, while soil conditions such as initial soil pH, exchangeable aluminum, exchangeable acidity, exchangeable bases, and base saturation were critical in determining the effects of soil physicochemical properties and crop yields under field conditions. Understanding the appropriate lime quality, placement methods, and agronomic management practices needed for specific crops and soil types to ensure sustainable soil health and crop yield is important to maximizing the benefits of lime materials in acid soil.

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GT 07 - 675 - P

FUNGAL COMPOSTING BIOREACTORS AS A SUSTAINABLE STRATEGY FOR AGRI-FOOD WASTE VALORIZATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The agri-food sector is among the most waste-intensive industries worldwide, it generates around 1.3 billion tons of solid and liquid waste each year. Effective waste management represents a sustainable opportunity to reduce environmental degradation. Reuse circular strategies reduce public health risks, and minimize economic burdens associated with waste generation and treatments. Fungi with lignocellulolytic capabilities play a key role in this context, as they can enhance the degradation of agro-industrial waste into a variety of high-value compounds with potential applications in composting procedures. Their eco-friendly nature contributes to improved soil fertility, supports beneficial microbial activity, and reduces reliance on anthropogenic inputs promoting key objectives in advancing circular agriculture. In this study, the composting of agri-food waste (AFW) was investigated using fungal microcosm bioreactor systems. Biomass residues from olive oil and citrus processing industries have been used as primary substrates, while Posidonia oceanica detritus and forestry pruning waste have been incorporated as bulking agents (BAs) to enhance porosity, aeration, and microbial accessibility. A comprehensive physicochemical characterization including measurements of moisture content, organic carbon, total nitrogen, pH, electrical conductivity, C/N ratio, and volatile compounds were conducted on both the AFW and BAs. Five fungal strains with established cellulolytic and ligninolytic activities (Aspergillus niger, Aspergillus tubingensis, Laetiporus sulphureus, Pleurotus ostreatus, and Trichoderma harzianum) were inoculated into microcosms to assess their biodegradation efficiency. The degradation processes were monitored through changes in nutrient composition, structural integrity, and maturity indicators. In addition, dual-energy computed tomography (DECT), as a non-destructive imaging technique, has been applied to track material density and degradation dynamics, offering insights into fungal colonization and substrate transformation. The study investigates and supports future technological developments of sustainable waste management and promotes possible AFW and BAs composting for soilless cultivation and crop production, closing nutrient loops and environmental impact of industries production in the mediterranean regions.

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GT 07 - 708 - P

LONG-TERM EFFECTS OF SEWAGE SLUDGE COMPOST APPLICATION ON SOIL CARBON AND NITROGEN SEQUESTRATION AND THE SOIL PHYSICAL PROPERTIES OF SANDY SOILS.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Sandy soils cover approximately 1.4 million hectares in Hungary, with the Nyírség region alone encompasses over 400.000 hectares. These soils are characterized by high porosity, low fertility preliminary, due to their low mineral and organic colloid content, which results in unfavourable chemical, physical, biological properties, and poor water holding capacity. Intensive land use and soil degradation processes have led to decline in soil organic matter (SOM) content. Applying organic waste composts can increase soil organic carbon (C) and nitrogen (N) content and carbon sequestration, furthermore enhance the physical properties of sandy soils. The objective of this work was to study the long-term effects of sewage sludge compost (SSC) application on C and N content, promote carbon sequestration, and improve physical properties of acidic sandy soils.

The long-term SSC experiment was established in 2003 and modified in 2006 at the experimental field of the Research Institute of Nyíregyháza, IAREF, University of Debrecen, Hungary. Detailed information regarding soil characteristics, climatic conditions, crop management, and experimental design can be accessed through the GLTEN database of Rothamsted Research (https://glten.org/experiments/166). In brief, the soil type is Dystric Arenosol, Aric, Cordic (WRB). This non-randomized small-plot experiment was conducted with five replications, applying SSC at rates of 0, 9, 18, and 27 t ha^{-1}, specifically formulated for acidic sandy soils. It contains 40% (m/m) of sewage sludge, 25% (m/m) of straw, 30% (m/m) of rhyolite, and 5% (m/m) of bentonite, and was ploughed to the 0–25 cm soil layer every third year. No additional organic or inorganic fertilizers were applied. The last SSC application prior to sampling was performed in 2021.

Composite and undisturbed soil samples were collected on 15 April 2024 from the depth of 0-10, 10-20, 20-30 and 30-40 cm from each plot for chemical and physical analysis. Total soil C and N content were measured with Dumas method (VarioMAX Cube elementar analyser, Elementar GmBH, DE). Macroaggregate stability in water was determined using the Eijkelkamp wet sieving apparatus. Based on the measured data, the C and N stocks as well as the macroaggregate stability index (MASI) were calculated for all sampled horizons.

Our findings demonstrate that regular, long-term application of SSC enhancing soil health by improving the C and N sequestration capacity and physical properties of acidic sandy soils, mitigating the negative effects of climate change.

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GT 07 - 715 - P

CO-CREATING URBAN CARBON SINK PARKS: LESSONS LEARNED FROM FIRST FIVE YEARS OF MONITORING THE CASE STUDY CARBON PARK IN HELSINKI

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 16. CONNECTING PEOPLE AND SOILS

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In order to achieve the goals of carbon (C) neutrality within next 20 year, municipalities worldwide need to increasingly apply negative emission technologies. Biochars, thanks to their stability against microbial degradation, suit well for application to both agricultural and urban soils- as a C- fixing technology providing multiple co-benefits, such as improved plant C fixation and reduced need for management. We explore the lessons learned from a co-creation process of one such park, Hyväntoivonpuisto demonstration area in Helsinki and the first five years of follow-up of the trees in biochar-containing growing media.

Demonstration sites of urban C sinks in public parks need to be safe, visible and scientifically sound. It is crucial to document well all practices, plan well the experimental design as well as methods for reliable and cost-effective verification of carbon sequestration. In order to tackle random variation, all treatments need to be randomised and replicated. Business-as-usual control treatment is needed to investigate the effect of the introduced practices in comparison to the current common practices. We find that different interests can be arbitrated and that synergy that emerges from co-creation of urban C sink parks between stakeholders (scientists, city officials, companies and citizens) can result in demo areas with maximized potential for impact, dissemination and consideration of principles of scientific experimentation.

To assess and demonstrate viability of biochars as component of urban planting soils, an experiment was established in 2019-2020 in Hyväntoivonpuisto-park in Helsinki. The experiment consists of four tree species and nine different planting soils, seven of which include biochars. Three of the planting soils were structural soils installed below a sealed surface. Tree growth in planting soils was followed and biomass accumulation was estimated with allometric equations in 2020-2025. Planting soil nutrient composition was analysed at the time of soil application and nine months later after first growing season. Further, pyrogenic carbon fractions were analysed by BPCA analysis. Planting soil physical and hydrological properties were analysed by water retention curves with pF range of 0 – 4.2.

After five growing seasons in autumn 2024, biochars had increased tree growth in two planting soils compared to the control while in other planting soils with biochar, the growth was similar to control. In structural soils biochars had no statistically significant effects in first years. Biochars increased the macroporosity of planting soils, indicating they could improve aeration and water conductivity in planting soils.

These results indicate that biochars are viable and safe constituent for planting soils which may increase tree growth by improving soil physical properties and improve carbon sinks in urban infrastructure.

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The growing media providers, city of Helsinki as well as the AgriChar group members.



GT 07 - 725 - P

VALORIZATION OF PAPER INDUSTRY RESIDUES AS SOIL AMENDMENTS FOR THE REMEDIATION OF CONTAMINATED SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The pulp and paper industry is one of the largest industrial sectors globally, with an annual production of over 182 million tons of pulp in 2022. Its manufacturing process is complex and involves three main stages: (i) raw material preparation, including debarking and chipping of wood; (ii) pulp production through chemical or mechanical processes, often accompanied by bleaching and refining steps; and (iii) paper formation and finishing, involving drying, rolling, and cutting. Throughout this production chain, a substantial amount of waste is generated. The cellulose fiber yield from raw wood is only about 40–50%, with the remainder resulting in residual biomass, including bark, wood fines, and significant amounts of sludge derived from the treatment of process effluents [1].

This work explores the valorization of two primary waste streams from the paper industry—woody residues (mainly bark and chips) and wastewater treatment sludges—as organic amendments for the remediation of contaminated soils [2]. Given their contrasting characteristics, particularly in terms of moisture content and organic composition, two distinct thermal conversion strategies were applied. The woody residues underwent pyrolysis at 550 °C for 20, 40, and 60 minutes, yielding three types of biochar with different physicochemical properties. Meanwhile, sludges, which contain high water content and complex organic matter, were processed via hydrothermal carbonization (HTC) at 200 °C, producing hydrochars from three different sludge types. Due to the presence of polycyclic aromatic hydrocarbons (PAHs) in the hydrochars, a subsequent self-refining treatment was carried out to enhance the environmental safety and stability of the material.

The resulting biochars and hydrochars were then tested as soil amendments in a laboratory-scale incubation experiment using a contaminated soil. The study assessed their effectiveness in immobilizing pollutants, their nutrient contribution to the soil, and their impact on soil carbon status. In particular, the potential of these materials to enhance soil organic carbon stocks was evaluated, with the aim of contributing to long-term carbon sequestration. This represents an additional environmental benefit aligned with climate change mitigation goals, positioning these amendments as tools not only for soil remediation but also for carbon sink generation. Preliminary results show marked differences in the performance of the two amendment types, highlighting the importance of tailoring treatment strategies to residue characteristics. Ongoing efforts are focused on scaling up the production of the most promising materials, with the goal of implementing them in field-scale trials to validate their effectiveness under real environmental conditions.

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GT 07 - 735 - P

PECULIARITIES OF SEA BUCKTHORN (HIPPOPHAE RHAMNOIDES L.) BIOMASS FORMATION DEPENDING ON SOIL ORGANIC MATTER CONTENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Sea buckthorn plants are known to be planted in order to minimize soil erosion. Their cultivation areas in Latvia are gradually increasing due to the demand for sea buckthorn products. Since the circulation of plant nutrients when cultivating sea buckthorn in the climatic conditions of Latvia has not been examined so far, there is also a lack of information on the optimization of fertilization of these plants. As the areas of sea buckthorn fields expand, more attention is paid to the agricultural technology of this crop, ensuring artificial irrigation, planning fertilization, as well as choosing the most suitable plant protection products. However, when observing the withering of sea buckthorn trees and a decrease in yield, farmers face a lack of knowledge, because it is unclear whether these problems are related to insufficient or excessive provision of plant nutrients. Therefore, a study was developed, the aim of which was to determine the accumulation of nutrients in sea buckthorn biomass and soil.

The study was developed at 56°64'80.4"N, 24°91'05.3"E. The plantation was established in 2018, using the sea buckthorn variety 'Marija'; total plantation area – 3.5 ha. Three different fertilization methods were used. (1). Control – no fertilizer is used (higher soil organic matter). (2) Organic fertilizer (compost), incorporated into the soil, kg ha-1: N – 38, P2O5 – 22.5 and K2O – 53.5. (3) Mineral fertilizer, incorporated into the soil, kg ha-1: P2O5 – 39 and K2O – 45. In 2023, 12 trees were harvested for trial purposes, four trees from each fertilizer variant. The obtained plant material was divided into five parts: berries, leaves, branches, stump and roots. The analysis was performed to determine the dry matter content of the biomass, as well as the chemical composition (nitrogen, phosphorus and potassium content in each part of the biomass). Soil profile description and sampling were performed to characterize the soil. In addition, soil samples were also taken around each harvested tree at two depths – 0 – 20 and 20 – 40 cm, which characterize the first two soil horizons. Soil pH, organic matter, total nitrogen, plant-available phosphorus and potassium were determined in the soil samples.

The results of the study found that on average, a sea buckthorn tree forms biomass in the following proportions: berries, leaves, branches, trunk, and roots are formed in the ratio 1.5:1:1.7:2.3:1.9. In sea buckthorn biomass, nitrogen accumulates mainly in berries and leaves, phosphorus in branches and leaves, while potassium in branches, berries and leaves. The average output of plants was N – 71 kg ha-1, P2O5 – 48 kg ha-1, K2O – 23 kg ha-1. The soil organic matter in the control variant potentially explains the differences in the output structure of plant biomass: greater accumulation of nutrients in the plant biomass that is directed to the formation of vegetative organs.

GT 07 - 747 - P

ASSESSMENT OF SOIL AND PLANT RESPONSES TO ADDITION OF FOUR MICROBIALLY-ENRICHED ORGANIC AMENDMENTS IN LETTUCE (LACTUCA SATIVA L.) PLANTS GROWN FOR A 60-DAY PERIOD IN MICROCOSMS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Agricultural use of organic by-products such as compost, solid digestate, vermicompost and biochar originated from processed biowastes represents a consolidated practice to enhance soil fertility and manage crop productivity. Recent progress in biowaste valorization has led to innovative amendment practices, such microbial fortification, that align with circular economy principles and sustainable agriculture goals.

This study, conducted within the frame of a PRIN2022 PNRR project P20223YAYP, funded by the European Union – Next Generation EU, aimed to assess the effects of addition of four organic amendments and singly applied at a rate of 0, 10, and 30 Mg ha-1, either enriched or not with a bacterial consortium constituted by Bacillus licheniformis, Bacillus subtilis, and Serratia plymuthica, on soil properties and lettuce (Lactuca sativa L. var. “romana”) plants grown in confined microcosm units under controlled conditions for a 60-day period. Monitored soil chemical properties were pH, electrical conductivity (EC), total organic carbon (TOC), and total nitrogen (TN). While total antioxidant capacity, total polyphenols, flavonoids, biomass production, leaf number, height, and root morphology were determined on lettuce plants soon after harvesting.

Findings showed that TOC increased with the higher dosage of biochar, while TN increased under higher dosage of compost, whatever the microbial enrichment. Whereas the pH remained unchanged and the EC fluctuated over time. Moreover, addition of compost, vermicompost, and solid digestate at the highest dose exerted a stimulatory effect biomass accumulation; in fact, significant increases were observed in the number of leaves, plant height, total fresh weight, and dry matter content when compared to unamended control. In terms of total antioxidant capacity, biochar and compost treatments consistently showed the highest values compared to the control, regardless of application rate. Each organic amendment can selectively affect the antioxidant status of the plant, potentially contributing to improved physiological resilience and nutritional quality. Not differences were found between enriched amendments, in-depth analysis are currently underway to investigate compositional shifts in rhizosphere prokaryotic community.

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GT 07 - 748 - P

SOIL SUITABILITY ASSESSMENT FOR SUSTAINABLE AGRICULTURE IN EUROPE: INTEGRATING SOIL CHARACTERISTICS AND CROP REQUIREMENTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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The Land Suitability Rating System is a rule-based set of algorithms integrating soil data to calculate a suitability class for a given soil to support commercial field crop production. From the soil point of view, the soil Suitability Rating (SR) index is a technical approach used to evaluate the suitability of a given soil type for various land uses. This index is based on an assessment of soil characteristics that affect its ability to support different kinds of crop production in an optimal way, without experiencing soil threats. The main objective of this work is to propose a two steps methodological approach to assess the agreement between soil suitability and actual crop production in Europe at parcel level (Fig 1).

Firstly, the experimental SR index was calculated for each soil sample from the LUCAS topsoil survey (Orgazzi et al. 2018). This is done by considering the crop soil requirements for a representative number of crops, as established in Global Agro-Ecological Zones (AEZ) modelling framework v4 guidelines (Fisher et al. 2021). The SR index is calculated for each soil sample from both the 2009 and 2018 LUCAS campaigns. Soil properties (silt, sand, clay, SOC, CEC, ECe, CaCO3, pH, soil depth, coarse fraction), directly measured in 21,683 and 18,744 soil samples respectively, are used to estimate various soil quality indicators. Soil suitability ratings were calculated for each level of input farming (low, intermediate, and high). These calculations considered the experimental soil parameters for each soil quality indicator and the 32 selected crops, taking into account two agricultural practices: rainfed and gravity irrigation.

Next, crop production is evaluated for each agricultural parcel in EU by comparing the resulting SR index and the existing crop in each agricultural parcel from IACS data (Wojda et al. 2023).

Preliminary results were obtained in line with the proposed methodology. The most suitable soil types are Kastanozem, Chernozem, and Andosol, which give high suitability ratings of 97%, 95%, 94%, and 94%, respectively. Moreover, the results of the soil suitability analysis reveal a varying degree of suitability across Europe at country level. Maps with a 500m spatial resolution are created using ordinary Kriging geospatial interpolation to extract the SR indices at parcel level, which are then merged with IACS data.

The analysis of soil suitability ratings across Europe by using data from agricultural parcels reveals a varying degree of suitability across countries, with some countries having higher suitability ratings than others. The soil Suitability Rating System is a valuable tool for assessing soil suitability for various land uses, including agriculture, forestry, and conservation. Thanks to the DG AGRI IACS data sharing process, established in collaboration with other stakeholders DGs notably DG ENV and DG CLIMA, with a support from the JRC, IACS data availability for re-use has been considerably increased.

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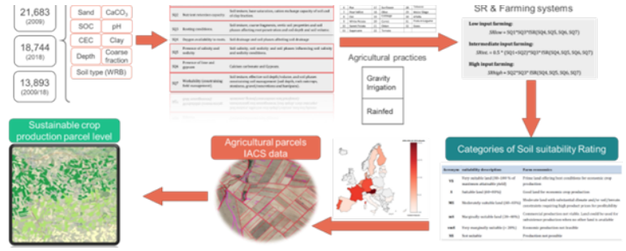


Figure 1. Methodological approach for determination of sustainable crop production at agronomic parcel level.



GT 07 - 749 - P

AGRONOMIC ASSESSMENT OF CHAR DERIVED FROM PYRO-GASIFIED PLASTIC-AMENDED FEEDSTOCKS: PHYSICOCHEMICAL PROPERTIES AND PHYTOTOXICITY EVALUATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Transforming plastic waste into char and its subsequent application to soil can enhance its nutrient content, physical structure, and long-term stability for improved agricultural performance. This study investigates the production, physicochemical characterization, and phytotoxicity assessment of chars produced via pyro-gasification of wood chips amended with different plastics: high-density polyethylene (HDPE), polypropylene (PP), and Plasmix (a mixed plastic waste stream). A control char derived exclusively from wood chips was included for comparison. Four feedstock compositions were tested in a pilot-scale pyro-gasification plant operating at 780-800 °C: PE (90% HDPE + 10% wood chips), PP (90% PP + 10% wood chips), PX (50% Plasmix + 50% wood chips), and WC (100% wood chips). Chars derived from PE, PP, PX, and WC displayed distinct physicochemical characteristics: PE and PP chars exhibited alkaline pH values (9.81–10.98), while PX was neutral (pH 7.7) with the lowest electrical conductivity (1.45 mS/cm). PE, PP, and PX contained higher levels of essential nutrients (P, N, K) compared to the wood-based char (WC). Heavy metal concentrations remained below standard limits in all samples except PP, which showed elevated levels (e.g., Ni: 365.9 mg/kg; Pb: 123.2 mg/kg). At low application rates (≤0.5%), most chars promoted seed germination, with PE achieving the highest germination index (GI >90%), while higher doses of PP, PX, and WC induced mild phytotoxicity, particularly in PP (GI <30%). Despite this, all char treatments enhanced plant growth compared to the control, with relative growth index (RGI) values exceeding 1.2. Although current legislation prohibits the use of plastic-derived materials, including plastic-derived biochar, as soil amendments, the relatively low phytotoxicity observed—particularly in char produced from mixed plastics and wood—highlights its potential for future environmental applications.

GT 07 - 768 - P

EFFECTS OF TEMPERATURES AND DIGESTATE PARTICLE SIZE ON SOIL PROPERTIES.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Digestate is the bioproduct obtained after anaerobic digestion of organic wastes in biogas plants. It is currently being applied to the soil as a fertiliser or organic amendment, receiving interest due to the remarkable potential and compared to other amendments or chemical fertilisers. The capacity of digestate to stimulate soil microorganisms is one of its main values that can be affected by the temperature and size of the bioproduct. One of the most important aims in the Ecoloop project (Horizon Europe Project) is to revalue by-products derived from the generation of renewable energy in the agricultural sector. Digestate from the anaerobic digestion of agri-food residues is used for achieving a fully circular economy. Agri-food wastes are generated in a specific area where the energy is produced, and the wastes of this process are used to improve soil quality. Digestate size and the soil temperature can affect soil improvement, and for this reason, this research determines the effect of temperature and digestate size on soil respiration, organic carbon, and enzymatic activity. Four particle sizes (diameter) were used: >4mm, 4-2mm, 2-1mm, and <1mm and an incubation was performed in the laboratory with hermetically sealed 250 mL flasks containing 29.9 g of soil and 0.1 g of digestate. The incubation temperatures were: 15, 25, and 35 °C.

Initial results show that the combination of soil with smaller digestate particles produces an increase in microbial respiration, perhaps due to the greater specific surface area of this type of particle, which translates into greater contact with the soil and greater accessibility by microorganisms. In relation to temperature, the soil with digestate incubated at 15 °C showed the lowest level of respiration during the experiment (4.12 mmol CO2kg-1), suggesting a reduction in microbial activity. In this case, the 4 mm size showed the lowest level of respiration. At 25 and 35ºC temperatures, the respiration rate was higher, but there were no differences between them (9.7 mmol CO2kg-1, 12.8 mmol CO2kg-1 respectively).

To sum up, soil respiration was more influenced by the size than by the temperature. However, this research has permitted to know in a Mediterranean condition, in spring and summer, when the average temperature in the area is around 25 ºC, is the most appropriate period to incorporate the digestate into the soil, since microbial activity is higher than in winter periods (10-15 ºC).

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GT 07 - 774 - P

DO COMMERCIAL BIOFERTILIZERS ALLOW A REDUCTION IN NITROGEN MINERAL FERTILIZATION IN EUCALYPTUS PRODUCTION?

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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This study aimed to evaluate the possibility of reducing nitrogen (N) mineral fertilization in eucalyptus (Eucalyptus globulus Labill) production, with the simultaneous application of biofertilizers, increasing sustainability in the forestry sector, while preserving soil fertility and biodiversity. Two commercial fertilizers were evaluated, one with arbuscular mycorrhizal fungus (AMF), Glomus iranicum var. tenuihypharum, and the other with a molecular N-fixing bacterium, Methylobacterium symbioticum. A 1-year experiment was set-up in semi-controlled conditions (50 L plant containers, outdoors, occasional irrigation), evaluating plant physiological parameters, overtime, mycorrhizal colonization, plant growth and nutritional status, and soil properties, at the end of the experiment. Four treatments were evaluated: (i) a control, without biofertilizers, (ii) inoculation with AMF, (iii) inoculation with N-fixing bacteria, and (iv) co-inoculation with AMF and bacteria. Three doses of mineral N were applied to each treatment, at transplantation: 100, 70 and 40% of the recommended N dose (four replicates per treatment), while the other macronutrients (P and K) were applied in the same dose (basal application. Plants which were simultaneously inoculated with both biofertilizers, with the lower mineral N-fertilizer application (40%), were those with a higher percentage of root colonization with AMF, with no significant differences from those with a similar mineral N application and inoculated G. iranicum, but with significantly higher colonization values than the control plants, without biofertilizers application, evidencing the successful symbiose between G. iranicum and eucalyptus, in nutritional stress conditions. Plants with the higher percentage of root colonization 40% N application) were also those with a higher foliar concentration of P, especially in co-inoculation conditions. At the end of the experiment, it was observed that a 30% reduction in the dose of N-mineral fertilizer led to a decrease in biomass production that only varied between 4.2% (inoculation with G. iranicum) and 13.4% (co-inoculation with G. iranicum and M. symbioticum), with no significant differences in relation to the production obtained with the higher dose of N-mineral fertilizer, suggesting that it is possible to reduce N-mineral fertilization in these soils, without compromising productivity. However, the 60% reduction in the dose of N-mineral fertilizer has caused a significant decrease in eucalyptus biomass production, not mitigated using biofertilizers, which was signaled six months after of transplantation by the chlorophyl relative index measurements, the most sensitive of the foliar vigor indexes used.

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GT 07 - 776 - P

SOURCE-SEPARATED SANITATION TO IMPROVE SOIL REMEDIATION POTENTIAL OF HUMAN MANURE-BASED SOIL AMENDMENTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Globally, around 340 billion kilograms of human feces is generated every year1 and the valuable resources in excreta – organic matter, microbes, and nutrients – could promote soil formation and revegetation on the 20-40% of degraded land-area, estimated by the UN.2 However, about 44% of human excreta is not safely managed, contaminating waters with harmful pathogens.3 On the flip side, high-income, industrialized countries use resource-intensive treatment processes and produce contaminated byproducts with limited application.

Biosolids, the solid byproduct of conventional wastewater treatment (WWT), sorb toxins like heavy metals and perfluoro alkyl substances from co-treated industrial waste streams, restricting their utilization.4 As much as 60% of biosolids are land-applied, despite concerns about contamination, and otherwise ends up in landfills, increasing GHG emissions.5,6 Novel resource recovery solutions are being explored, however, they are costly and require complex infrastructure and technical expertise.7 Alternatively, separating excreta at the source can achieve 100% recovery and enable low-tech treatment processes, like composting, to produce soil amendments.8-10 Historically, similar practices sustained farming in the degraded soils of Japan, and built-up persistent carbon stores in the Amazon.11-12

Our study tests the hypothesis that, along with a smaller environmental footprint, source separation can produce a better soil amendment than conventional WWT, specifically for remediation efforts like mine closure. Source separated, aerobic compost (SS-compost) likely improves soil stability, has greater sorption capacity, and forms more stable metal complexes, even in acidic conditions when metals are generally mobilized, compared to biosolids. SS-compost has a high content of oxygen functionalities that complex metals and aggregate soils at neutral pH and still offer some stability through H-bonding when protonated at low pH.13,14 Biosolids, digested in anaerobic conditions, lose many of these hydrophilic humic substances to the liquid phase.4 Anerobic digestion breaks down organic matter into mostly aliphatic carbon whereas composting generates aromaticity which promote pi-pi bonding even at low pH.4,13,14 Finally, while biosolids are pre-loaded with toxins, SS-compost can be kept separate even from urine, decreasing contaminant, salt, and nutrient loading to increase its sorption capacity and minimize deleterious environmental effects.4,15,16

Here we compare biosolids and SS-compost for their promotion of soil aggregation and metal complexation, prerequisites for revegetation and pollution mitigation, in mine waste rock collected from Idaho Springs, CO12,13 and test stability in acidic conditions. Finally, we explore the link between organic waste management, water quality, and soil health and how integrating their management could sustainably improve environmental and human health outcomes.

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GT 07 - 787 - P

BIOCHAR EFFECTS ON SOIL HYDROPHYSICAL AND CHEMICAL PROPERTIES: TEXTURE AND PARTICLE SIZE MATTER

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Climate change poses critical challenges to soil and crop systems, particularly through increased drought frequency. Biochar, a carbon-rich byproduct of biomass pyrolysis, has been proposed as a nature-based solution to enhance soil climate resilience. However, the variability in biochar effects across different soil types complicates the predictability of its outcomes and economic viability. This study systematically investigates the effects of biochar on the hydrophysical and chemical properties of soils with contrasting textures (sand, silt loam, and clay).

We selected one hardwood-derived biochar, sieved it into two particle size fractions (63–200 µm and <63 µm), and mixed them to produce three biochar types with particle sizes ranging from 2 to 200 µm. These biochars were mixed with the soils at application rates of 0%, 1%, and 5% (w/w), resulting in 21 unique soil-biochar mixtures (SBMs) including controls. Key soil properties – including pH, electrical conductivity (EC), bulk density (BD), unsaturated and saturated hydraulic conductivity (K and K_s), water retention characteristics (θ), and plant-available water (AW) – were quantified, following a 113-day incubation with an initial 15% (w/w) water addition at 18°C and a subsequent air drying <45 °C.

Results revealed significantly improved AW and K in sand, enhanced K_s, BD, and total porosity in silt loam, and moderately altered water availability and K_s in clay. The effects were strongly influenced by both soil texture and biochar particle size, with fine biochars at higher application rates generally producing the most pronounced effects. A consistent pattern in water retention and flow characteristics was observed in relation to the particle size distribution of both soil and biochar in the SBMs. Moreover, pH increased substantially in biochar-amended sand treatments, while changes in silt loam and clay were moderate to minimal, respectively.

This study underscores the necessity of texture-specific biochar application strategies and supports biochar's role as a viable tool for enhancing soil water regulation and resilience in agricultural systems. Further experiments with exhaustive input data will facilitate accurate predictability of soil-biochar interaction, improving our preparedness for soil-related climate change risks.

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GT 07 - 805 - P

EFFECTIVENESS OF COMBINED COMPOSTING AND VERMICOMPOSTING IN THE MANAGEMENT OF VINEYARD PRUNING AND SEWAGE SLUDGE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The direct application of vineyard pruning (VP) and sewage sludge (SS) to soil poses significant ecological challenges, despite their richness in nutrients and organic matter. Composting is widely recognised as an efficient approach to manage these wastes, transforming them into stable nutrient-rich compost. However, the advantages of combining composting and vermicomposting are not well understood. In this study, composting was used as a pre-treatment method for processing VP and SS, followed by vermicomposting using Eisenia fetida. Three mixtures (M1, M2, and M3) were prepared with varying proportions of VP and SS, based on their C:N ratios and moisture content. The solid fraction of cattle slurry was used as inoculum to enhance the process. The quality and maturity of the end products were evaluated by determining the physical and chemical parameters, along with the germination index (GI). A comparative analysis was conducted between the composting process and the combined composting-vermicomposting process. The results showed that both processes produced final products that met the requirements established in the Portuguese legislation (Portaria No. 185/2022), making them suitable for soil application. Of the mixtures, M3 emerged as the most balanced in terms of its potential effects on soil and nutrient availability, particularly nitrogen, in both processes, composting and vermicomposting. Moreover, the M3 mixture exhibited higher GI compared to M1 and M2. In conclusion, combining composting and vermicomposting enhances the quality of VP and SS waste, providing a sustainable option for their management.

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GT 07 - 806 - P

USE OF VINEYARD RESIDUES AND SEWAGE SLUDGE IN SUBSTRATES: A SUSTAINABLE SOLUTION FOR CUCUMBER PRODUCTION?

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Viticulture generates large amounts of waste annually, particularly from pre-pruning and pruning operations, which are commonly managed by burning or shredding. Composting and vermicomposting are environmental and agronomically beneficial alternatives for managing this biomass. This study aimed to evaluate the use in substrate formulation of composted (CO) and vermicomposted (VC) mixtures of vineyard residues and sewage sludge, for cucumber cultivation. Five substrate formulations were tested: two with CO and two with VC, each mixed with a commercial peat-perlite substrate (PP) in the proportions of 10% CO + 90% PP, 20% CO + 80% PP, 10% VC + 90% PP, and 20% VC + 80% PP. The PP substrate alone served as control. Cucumber seeds (cv. Marketer) were sown in seedling trays, and germination was evaluated at 3, 5, 7, and 10 days after sowing. After 22 days, several growth parameters were measured, including shoot height, root length, fresh and dry biomass (shoot and root), number of leaves, leaf area, and relative chlorophyll content (SPAD index). Results showed that germination and plant growth were higher in VC-containing formulations compared to those with CO. The substrate with 10% VC showed the best overall performance, suggesting that its inclusion on substrate formulations enriches the substrate and contributes to the sustainable and circular use of organic vineyard and urban residues.

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GT 07 - 811 - P

IMPACT OF SOIL TEXTURE AND BIOCHAR ON CARBON CONTENT IN MINE SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Mining serves as a prominent illustration of land degradation, as the ecosystem at a site is entirely removed and frequently subjected to extensive reconstruction or rehabilitation. This research investigates the use of biochar in the rehabilitation of degraded mine soils, aiming to enhance carbon sequestration and improve soil quality. Three experimental conditions were established: (1) untreated mine soils (control), (2) mine soils amended with biochar at concentrations of (1%, 3%, 5%), and (3) mixtures of mine soil with 10% clay and biochar at (1%, 3%, 5%). The results indicate that soil texture affects the carbon percentage in treated soils. Biochar demonstrates a significantly greater increase in soil organic carbon (SOC), with optimal results anticipated at a 5% application rate. The modification of soil texture through the addition of finer particles improves these properties by enhancing soil structure and increasing nutrient retention capabilities. This study presents practical implications for the sustainable rehabilitation of mining soils through the use of biochar, thereby contributing to nature-based solutions.



GT 07 - 819 - P

PERFORMANCE OF NITROGEN- AND PHOSPHORUS-IMPREGNATED BIOCHAR-BASED FERTILIZERS COMPARED TO CONVENTIONAL FERTILIZERS IN HIGH PHOSPHORUS-FIXING ANDISOLS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Excessive reliance on synthetic nitrogen (N) and phosphorus (P) fertilizers has led to nutrient losses and environmental degradation, particularly in high P-fixing Andisols where fertilizer efficiency is severely constrained. This study evaluated a biochar-based controlled-release fertilizer (BAPF), synthesized by impregnating oat hull biochar with urea and diammonium phosphate to enhance nutrient use efficiency and crop productivity in volcanic soils.

Physicochemical characterization confirmed successful N and P incorporation into the biochar matrix, modifying its structure and functional groups. In an 8-week soil incubation, BAPF demonstrated superior nutrient retention compared to conventional fertilization (CF), with 6% more total N and over 20% greater available P by day 60. Apparent nutrient recovery improved notably: nitrogen recovery increased from 36.5% (CF) to 55.0% (BAPF), and phosphorus recovery more than doubled (from 8.9% to 18.5%).

Under greenhouse conditions, wheat plants fertilized with BAPF showed 15% higher grain yield and 19% greater N uptake than CF-treated plants, with enhanced biomass and nutrient assimilation. Field trials during the 2023–2024 season validated these findings in real cropping conditions: the top BAPF treatment (BC350P) achieved 135 qq/ha of grain yield, improved canopy development (LAI = 10.05), photosynthetic activity (15.0 µmol m^{-2} s^{-1}), and maintained NDVI values above 0.77 during grain filling. Grain protein content exceeded 10.8%, and BAPF sustained higher mineralizable N levels at harvest while reducing nitrate accumulation.

These results highlight the agronomic and environmental advantages of dual-nutrient impregnated BAPF in Andisols, where allophanic clays strongly limit P availability. Its gradual nutrient release, aligned with crop demand, enhances nutrient recovery, reduces losses, and supports sustainable intensification in temperate, volcanic agroecosystems.

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GT 07 - 855 - P

MICROBIAL ACTIVITY INDICATORS IN OLIVE POMACE COMPOSTING

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Olive pomace (OP) is a by-product generated during the olive oil extraction process, particularly in the two-phase system commonly used in Mediterranean countries such as Portugal and Spain. This process produces large volumes of OP, characterized by high moisture content, residual fats and phenolic compounds, high amount of organic carbon, and low porosity, which renders OP highly phytotoxic and unsuitable for direct soil application without treatment. These characteristics make its management challenging and, in some cases, economically unfeasible. In this study, the industrial-scale composting of OP was evaluated using two bulking agents, forest biomass (FB) and almond shells (AS) with a focus on microbiological activity indicators over time. Pre-fermented OP (100%) and two raw material mixtures were tested: OPFB (50% OP + 50% FB) and OPAS (50% OP + 50% AS). The composting process was monitored over 155 days, during which nine composite samples were collected and analyzed for their physicochemical parameters (pH, electrical conductivity (EC), and ash content), elemental composition (C, H, N, O), allowing the calculation of O/C, C/N, and H/C ratios, and phytotoxicity. Temperature was continuously monitored, and enzymatic activities (cellulase) were assessed in the mature composts (OPFB, OPAS), and in a sample of thermophilic OP compost sample (TR). Multivariate statistical analysis was applied to evaluate the variation in the relation among analytic parameters throughout the time. The results showed that microbial activity (measured in different composting phases) were more strongly associated with changes in physicochemical properties in time, than with the type of bulking agent used, highlighting the dynamics of organic matter degradation. Cellulase activity was notably higher during the thermophilic phase (TR), marked by elevated temperatures, compared to the maturation phase, indicating greater microbial activity during the active stage and confirming the chemical and microbiological stability of the final compost. These findings demonstrate that composting is an effective strategy for managing large volumes of OP, enabling the production of a stable, non-phytotoxic product and contributing to the circular economy and the sustainability of the agro-industrial sector.

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GT 07 - 869 - P

PRELIMINARY INSIGHTS INTO THE SYNERGISTIC USE OF AGRICULTURAL ORGANIC AMENDMENTS: MITIGATION OF TOXICITY AND NUTRIENT ENHANCEMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The use of different soil organic amendment offers potential agronomic and environmental benefits, both from the point of view of physical and chemical fertility. However, the literature evidence findings on their effects remain contradictory (Rayne & Aula, 2020), with outcomes ranging from enhanced fertility and microbial activity (Aytenew & Bore, 2020; Hasan et al., 2024) to negligible or even adverse changes in soil properties (Huang et al., 2019) under different conditions. These inconsistencies underscore the complexity of evaluating agronomic benefits across diverse contexts and hinder the reuse and valorisation of such amendments, highlighting the need for more situation-specific approaches to harness their benefits for truly sustainable land management.

This work is focus on the combination of solid and liquid organic amendments derived from agricultural and livestock waste with the objective of reducing possible negative effects and improve its biofertiliser potential.

This contribution shows preliminary results after evaluating the application of agro-forest green waste biochar and its combination with three different liquid organic amendments (cattle manure slurry, urban compost tea and cattle digestate). Two contrasting soils were used for amendment application: a calcareous soil from southwestern Spain and an acidic soil from the northwest. The effect of the different formulates on seed germination and growth of barley plants was also analysed.

The results obtained reveal that the combination of the amendments can reduce toxicity effect of some compounds that could limit the liquid amendment use in a direct application to the soil. Concurrently, biochar mix with liquid amendments produce a partial improvement on the nutrient content of the formulated leading to optimised resource management which contributes to a higher sustainability in the agricultural sector.

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GT 07 - 870 - P

COMPOST-DRIVEN CHANGES IN THE MICROBIOLOGICAL PROPERTIES OF A DEGRADED BROWNFIELD SITE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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In this study, we focused on evaluating the impact of horticultural compost application on the microbiological properties of a rural brownfield site. Ten sampling sites were assessed across three locations, with five samples collected from each. Laboratory analyses were conducted to determine pH, soil texture, total organic carbon, microbial biomass and respiration, cellulolytic activity, total bacterial counts, the relative abundance of microscopic fungi, and values of ecophysiological indicators (microbial quotient and substrate availability index). Immediately after compost application, various fruit trees were planted at the site. Each analysis was performed in triplicate. The analyses were repeated four months after the compost application. The compost application had a measurable effect on specific soil properties, as indicated by principal component analysis (PCA) results, which showed a positive response of the microbial community to the addition of organic matter. Samples taken before the application were dispersed within the PCA space. In contrast, post-application samples tended to cluster closer to the centre of the coordinate system, suggesting a reduction in the heterogeneity of soil properties. Soil microorganisms responded to the compost amendment by increasing microbial biomass and enhancing soil respiration potential, indicating elevated microbial activity due to improved nutrient availability. In contrast, basal respiration showed a slight decrease in some cases, possibly related to changes in the quality of available carbon sources. Multivariate analysis of variance confirmed that compost application had a statistically significant effect on the entire set of analysed variables (Wilks' Lambda = 0.234; $F = 3.72$; $p = 0.011$). To verify the individual impact of compost on specific variables, paired t-tests were applied. Significant differences between groups were found in the following parameters: soil microbial biomass ($p < 0.03$), soil respiration ($p < 0.02$), and pH ($p < 0.04$). The dominant changes were thus mainly associated with microbial carbon and soil respiration, indicating that compost stimulated microbial activity. Conversely, the parameters of ecophysiological indicators appeared relatively stable, with only minor differences. Overall, the results suggest that compost application contributed to the improvement of several biological and chemical soil properties, and these positive trends were observed even within a short-term timeframe.

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GT 07 - 876 - P

PHOSPHORUS PHASES AND AVAILABILITY IN SEWAGE SLUDGE FROM DIFFERENT GENERATION REGIONS IN JAPAN AFTER THE COMPOSTING, COMBUSTION, AND MELTING

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 02. SOIL PHYSICAL CHEMISTRY

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The phosphorus phases and availability in sewage sludge depend on the region where the sewage sludge is generated, and coagulant types. These are also altered by the sludge treatments such as the composting, combustion, and melting even for the same sludge. In the melting, the sewage sludge is melted at a high temperature of around 1,400°C, which volatilizes toxic metal(loid)s and do not remain such metal(loid)s in the molten sludge, resulting in the environment-friendly material. In addition, the molten sludge has high phosphorus content, making the molten sludge motivated to be used for agricultural purposes. However, understanding how each sludge treatment alters the phosphorus phases and availability depending on the sludge type is important to clarify the phosphorus availability of molten sludge as a sewage sludge-derived fertilizer compared with the other treatments. This study aimed to clarify the differences of phosphorus phases and availability of molten sludge as the sewage sludge-derived fertilizer from the other treatments. This study collected three sewage sludges from the waste water plant located at different regions in Japan. These sludges differ depending on the coagulant type and whether or not they are methane fermented, and were treated with the composting, combustion, and melting. The untreated sludge was used as control. After the treatment, the phosphorus phases in the treated sludge were evaluated by sequential extraction. The phosphorus availability in the treated sludge was determined by the extraction with a solution containing citric acid with the different extraction strengths (water, pH7 ammonium citrate (AC), pH 4.5 AC, and citric acid (CA)). The concentrations of iron, aluminum, calcium, and magnesium as well as phosphorus in each extractant were measured, and the amount of each element extracted was determined. The phosphorus phases in the untreated sludge differed among sludge types, which would be resulted from the types of coagulant and methane fermentation. Compared to untreated sludge, some composted sludge had more soluble phosphorus phases and some had more insoluble phosphorus phases, resulting in greater differences in phosphorus availability among sludge types. However, they did not bring about as much change as the differences in phosphorus phases and phosphorus availability among the sludge types. Phosphorus availability decreased with combustion compared to untreated sludge while phosphorus phases and availability were similar among sludge types. In similar as the combustion, the melting resulted in similar phosphorus phases among the sludge types. However, the melting increased the phosphorus availability compared to the combustion, and caused the phosphorus availability differed among sludge types. The phosphorus availability in the molten sludge would depend on the solubility of the molten sludge itself, but further study should clarify the phosphorus release process from the molten sludge.

Fig. 1 (a) Phosphorus phases by sequential extraction and (b) its availability by extraction with a solution containing citric acid with the different extraction strengths in molten slag (MS)

GT 07 - 882 - P

CHARACTERIZATION OF DIFFERENT BIOCHARS FOR USE AS URBAN SOIL AMENDMENT IN A CIRCULAR ECONOMY APPROACH.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Urban soils are degraded soils under strong human influence that could have very stressful conditions for urban trees. Therefore, the search for improvements of such soils that lead to a better survival of “urban forests”, which provide important ecosystem services in cities, is of great interest. Biochar generated from local organic waste in a circular economy context, is an alternative to be studied. This work is part of the DEMETER Project (El Ejidillo Viveros Integrales S.L. - CIEMAT) and focuses on studying the feasibility of different types of biochars to improve urban soil conditions, including increasing its capacity as a carbon sink in the context of the fight against climate change.

The biochars studied were: 4 biochars pyrolysed between 780°C and 820°C (biochar from poultry manure, biochar from annual vine pruning, biochar from horse manure and biochar from annual almond tree pruning); a commercial biochar (CB) generated from hardwoods (hornbeam and oak) pyrolysed at 450°C; and a biochar from plane tree (PB) (Platanus x hispanica) pyrolysed at 480°C. A general characterization of the biochars was carried out, consisting on pH, EC, available P (POlsen), N Kjeldahl, phytotoxicity and soluble ions in aqueous extract. In addition, an elemental analysis and FTIR and SEM studies was carried out; and the percentages of moisture, volatile material, ash and fixed C were measured.

The results obtained show that CB and PB are the best options among the alternatives considered. They meet the objectives of increasing carbon in the soil, with high stability and a higher percentage of C fixed. Their use rules out possible soil salinization problems. They also have high values of available P and are not phytotoxic. Although CB is a cheaper and more readily available alternative because it is commercially available, PB is a very good alternative for further study. Plane tree (Platanus x hispanicus) is currently widely present in urban tree plantations in temperate and Mediterranean areas of Europe and generates large quantities of prunings per year that could be revalued by converting them into biochar for urban soil improvement or other uses, in a circular economy context.

ACKNOWLEDGEMENTS

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GT 07 - 883 - P

EFFECTS OF DIFFERENT DAIRY SHEEP MANURE COMPOST WITH BIOCHAR ON AGRICULTURAL PRODUCTIVITY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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This work is part of the EU-funded ConnectFarms project, which explores integrated crop-livestock production systems from a circular economy approach. Animal residues are converted into soil amendments that will improve crops, which in turn can be used as animal feed. In this project, biochar was used to improve dairy sheep manure characteristics in terms of its suitability for a more sustainable composting procedure. NEIKER (Basque Institute for Agricultural Research and Development, Spain) used biochar as a feed additive and biochar itself as a bulking agent for composting to solve the environmental trade-offs of compost. The aim of this study was to evaluate the effects of the different composts obtained on soil fertility and agricultural productivity.

The experimental work was carried out on pots filled with calcareous soil from Buendía (Cuenca, Spain) using barley variety Planet as a test crop. The soil correspond to the upper horizon up to 50 cm in depth. The experiment was carried out during 4 months in a completely randomized design into a growth chamber under the following conditions: soil at 60 % of water holding capacity, 16 hours day and 8 hours night, temperature 25°C/19°C (day/night), 50 % of relative humidity and 60 % of ventilation. The treatments in triplicate included 1) Traditional fertilization (TF); 2) Sheep manure compost (C); 3) Sheep manure compost + 10 % biochar (B10) and Biochar-fed sheep manure compost (BD). We performed a monitoring of inorganic anion and cation composition, and available P of soil solution during the vegetation cycle of barley (sowing, ear emergence and harvest). Furthermore, plants were harvested at maturity and plant weight and height; number of ears; and number and weight of grains were recorded per pot as composed sample.

The results show that the best germination success was obtained in the soil with C followed by the soil with B10 and finally by the soils with TF and BD. In addition, the highest yield value was obtained with the use of TF, C and B10 while the lowest was obtained with BD despite having similar germination success values to those obtained in the case of TF. In conclusion biochar-fed sheep manure compost (BD) seems to affect plant development, leading to the worst grain yield results in calcareous soil, which could be related to high values of Cl-.

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GT 07 - 885 - P

EFFECT OF INTEGRATED USE OF SOIL AMENDMENTS AND NANO FERTILIZERS ON SOIL PROPERTIES, PLANT GROWTH AND YIELD OF STRAWBERRY UNDER TEMPERATE CONDITIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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A pot experiment was conducted during Rabi of 2020, at the Faculty of Horticulture, SKUAST Kashmir, Shalimar Srinagar, to study the effect of integrated use of soil amendments and nano fertilizers on soil properties, plant growth and yield of strawberry under temperate conditions. The experiment was laid out in CRD with three replications and 10 treatments taking no of pots to 30. Among the different treatments, T8 (Neem Cake @ 50%+ Nano Zeolite @ 5 g kg-1 soil + RDF 50%) proved superior to RDF and control and obtained higher values of growth parameters, grain and biological yield. Increase in almost all the growth parameters resulted in significant improvement in yield attributes which led to the significantly highest grain yield. Sole or combined application of soil amendments (Nano Zeolite) along with 100 % RDF through inorganic fertilizers performed better than 100 % RDF alone in terms of shoot and root parameters, crop yield and improvement of soil properties. Treatment T8 proved to be a promising combination and recorded significantly higher values for viz., Leaf area (125.71 cm2), Chlorophyll content (53.68 SPAD), leaf relative water content (85.67%), Duration of flowers (36.68 Days), No. of flowers per plant (22.62), Fruit set (70.66), Time taken to maturity (17 Days), Number of Fruits per plant (15.63), fruit yield pe plant (336.31 g/pot), Biological yield (364.95g/pot), Fruit weight (21.44 g), Fruit length (35.561 mm), Fruit Breadth (34.481 mm), Fruit length/breadth ratio(1.041), TSS (11.360B), Titratable Acidity (0.92 %), Total sugar content (8.05%), Reducing sugars (6.81%), Porosity (49.35 %), Infiltration rate (0.48%), pH (7.24), EC (0.69dS/m), OC (0.51%), Available N (306.99kg/ha), Available P (20.45 kg/ha), Available K (292.46 kg/ha), Zn (077 ppm), Fe (2.63 ppm), Cu(0.32 ppm), Mn(2.60 ppm)compared to other treatments.While as, the highest Bulk density (1.35 g/cm1), Particle density (2.61g/cm) was recorded in T10 Control (Untreated)It is concluded form the study that Neem cake and nano fertilizers along with nano zeolite proved superior to RDF and Control. The treatment T8 exhibited superior outcomes in terms of growth, fruiting, yield and quality parameters. Contrastingly, T10 yielded the lowest results. The findings highlighted a synergistic effect among the resources, creating favorable microclimatic conditions during the crop growth period, enhanced soil properties without compromising overall yield. These results shall contribute to the advancement of efficient and sustainable cultivation practices, enabling growers to optimize production in Strawberry cultivation.

KEYWORDS

Nano Fertilizers, Neem Cake, Soil Amendements, Nano Zeolites, Strawberry Cultivation,

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Effect of Nano fertilizers on leaf water content



GT 07 - 888 - P

AQUASTEADY: AN ALGINATE-DERIVED HYDROGEL TO IMPROVE SOIL WATER AVAILABILITY

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Alginate derived from brown algae is a polysaccharide composed of repeating units of D-mannuronic (M) and L-guluronic (G) acids in a β-1,4 structure in varying proportions, forming hydrogels through physical-chemical bonds. These materials can be hydrated to more than 100 times their weight and, when applied to the soil, increases the volumetric soil moisture to near field capacity (-33 kPa). AquaSteady is a product under development that can improve water availability for crops during times of water stress. Trials were conducted to evaluate the effect of AquaSteady concentrations applied to soil in pots and AquaSteady levels applied to soil in the field, under optimal and deficient irrigation, on the development and yield of beans (Phaseolus vulgaris). In pot trials, AquaSteady concentrations between 0.1 to 0.4% (w/w) applied to Cumulic Haplustolls increased bean biomass by 21 to 55% under optimal irrigation but did not affect biomass under deficit irrigation. In a field trial on a Typic Haplustert, bean yield was not affected by AquaSteady levels of 0, 2,000, and 4,000 kg/ha in both irrigation regimes. The germination and initial development of pumpkin (Cucurbita moschata) seedlings were evaluated in Lamber LM-2(®) growth medium with AquaSteady concentrations between 0.01 to 1% (w/w), and there was no effect of AquaSteady under either optimal or deficit irrigation. Trials are continuing to evaluate the effect of AquaSteady on crop yield and the mechanisms by which the product improves water availability in soils.

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GT 07 - 897 - P

EFFECT OF CONTROLLED-RELEASE FERTILIZER ON REDUCING AMMONIA EMISSIONS: FINDINGS FROM FIELD EXPERIMENTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The European Union is making increasing efforts to reduce air pollutant emissions - including ammonia - to meet the goal of NEC Directive 2016/2284. All EU countries have to set an annual total emission limit to be met by 2030, for example Hungary must reduce ammonia emissions by 32% compared to 2005 levels. Since 90% of ammonia emissions originate from agriculture, in line with sustainable agriculture ambitions, modifications in agrotechnical practices are necessary to meet the aforementioned target.

Our research aims to identify optimal agricultural management practices to minimize ammonia emissions, thereby creating synergies between reducing land degradation and achieving climate neutrality. A field experiment series was conducted to explore methods of reducing ammonia losses from urea fertilizer (46.6% active nitrogen content) through different agrotechnical treatment combinations—split-dose fertilizer application (60-40%) and incorporation—considering various test crops (wheat, triticale, grain sorghum, maize, sunflower), soil properties and climatic factors. The study tested the urease inhibitor (Limus Yellow), designed to slow the hydrolysis of urea by inhibiting urease enzymes, thus reducing ammonium formation and ammonia loss.

The experiment was set up in a randomized design with four replications, including control plots with a total of 32 plots across four different soil types: Arenosol, Chernozem, Luvisol, and Gleyic Chernozem (WRB 2014), representing sandy, loamy, and clayey loam textures. Ammonia volatilization was measured using passive chamber method (phosphoric acid and glycerol mixture as an NH_3 trap) over a period of six weeks for hoe crops and twelve weeks for cereals, with ammonia release determined at two-week intervals.

The urease inhibitor effectively delayed the ammonification process in all soil types, reducing ammonia emissions in the weeks following application, although with a declining effect over time. The ranking of soils in terms of ammonia reduction due to the inhibitor (based on two-year averages) was as follows: Arenosol (52%) > Chernozem (50%) > Luvisol (46%) > Gleyic Chernozem (20%), indicating a correlation between soil texture, with reductions decreasing as clay content increased.

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	Őrbottyán Arenosol			Nagyhörcsök Chernozem Soil			Karcag Gleyic Chernozem Soil		Keszthely Luvisol	
	2019 Maize	2021 Triticale	2022 Triticale	2020 Maize	2021 Winter wheat	2022 Winter wheat	2021 Grain sorghum	2022 Winter wheat	2021 Maize	2022 Sunflower
INHIBITOR decreased	39%	48%	51%	45%	56%	51%	3%	41%	35%	58%
INCORPORATION decreased	43%	-	-	86%	-	-	68%	-	72%	39%
SPLIT-DOSE APPLICATION decreased	-	23%	16%	-	28%	16%	-	26%	-	-

Impact of different agrotechnic applications on annual ammonia emissions considering different soil types and test crops



GT 07 - 899 - P

SOIL: A TOOL FOR THE BIOREMEDIATION OF DEPOLYMERIZED POLYURETHANE WASTE VIA OZONOLYSIS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Polyurethane (PU) is a type of non-biodegradable plastic polymer that exhibits high durability in the environment, with its recycling being limited to landfill accumulation, incineration, or chemical recycling. Our group has developed a novel chemical recycling process through ozonolysis that achieves complete depolymerization and solubilization of PU in water, with zero carbon footprint, requiring only renewable electric energy and water, which is recycled and reused throughout the process.The depolymerized PU results in an aqueous extract (OLE), composed of low molecular weight molecules (<600 Da) derived from the breakdown of the polyurethane molecule. This extract is rich in carbon and nitrogen, making it a potential biostimulant/biofertilizer for soil microorganisms. Soil would function as a complex tool for the biotransformation of these molecules into microbial biomass. Microorganisms present in the soil showed an increase in soil microbial activity, indicating the activation of metabolic pathways capable of metabolizing the molecules found in the OLE. Bacteria belonging to the genera Bacillus, Luteimonas, and Flavobacterium, and fungi from the genera Humicola, Solicoccozyma, Fusarium, and Aspergillus, among others, have been detected in soils where the biodegradation capacity of different OLE concentrations by these microorganisms has been studied. These microorganisms are of particular interest due to their properties as PGP (Plant Growth-Promoting) microorganisms. Through the synthesis of enzymes involved in the degradation of plastic polymers—such as cutinases, esterases, hydrolases, and oxidoreductases, among others—these microbes would enable the bioconversion of the chemical molecules comprising OLE into biomolecules like sugars, proteins, and fatty acids. This novel two-phase chemical-biological process is proposed as a potential total recycling solution for polyurethane, using soils as a tool for the bioremediation of a highly recalcitrant waste.

Abstract JMO Soil. A Tool for the Bioremediation of Depolymerized Polyurethane Waste via Ozonolysis.pdf

GT 07 - 912 - P

EFFECT OF THE COMBINATION OF BIOSTIMULANT MICROBIAL SECRETIONS AND ALGAE COMPOST ON PLANT GROWTH IN ALKALINE SALINE IRON-DEFICIENT SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The increasing demand for sustainable crop fertilization highlights the importance of developing alternative fertilizers and reducing reliance on chemical inputs, which can compromise soil health and water quality. A promising approach involves the valorization of environmental waste, such as algae wash-ups from the Mar Menor lagoon, by transforming them into nutrient-rich compost. In parallel, Plant Growth-Promoting Rhizobacteria (PGPR) from Pseudomonas group produce secretions containing pyoverdine – a yellow-green fluorescent siderophore that functions as a biodegradable iron chelate – along with other biostimulant metabolites [1,2]. In this study, the biofertilizer and PGP effects of secretions from the Pseudomonas fluorescens RMC4 strain (S), Mar Menor algae compost (C), and their combination (CS) were evaluated on lettuce plants (Lactuca sativa) grown in iron-deficient alkaline saline soil.

Various biochemical analyses were conducted on the plants, including evaluations of Nitrogen Balance Index (NBI), chlorophyll surface content, and epidermal flavonol and anthocyanin indexes using a Dualex leaf clip optical sensor. Reactive Oxygen Species (ROS) were quantified through 2',7' –dichlorofluorescin diacetate staining, and photosynthetic pigments were determined via colorimetry. Elemental analyses were performed using ICP-OES and AAS after soluble and available soil extractions and mineralization of the plant. A comprehensive soil characterization was performed after plant growth. Soil enzyme activity of β-glucosidase, urease, phosphatase, and arylsulphatase was determined following the ISO 20130:2018 standard, in addition to dehydrogenase activity (DH).

Secretion (S, CS) increased soil soluble Na, P, and Fe, with positive effects of treatment S on plant nitrogen utilization efficiency and increased leaf P content. Compost application (C, CS) lowered soil pH and increased electrical conductivity, organic matter, nutrient solubility (S, Mg, Ca, B, Zn) and availability (Fe, Mn, Zn), and DH activity; enhancing plant yield while reducing Mn content. Although S and C treatments reduced plant stress, CS resulted in higher ROS values.

In conclusion, algae compost improved soil properties and plant yield while Pseudomonas florescens RMC4 secretions contributed to soil Fe solubilization and may have promoted P mobilization. However, the combined application of compost and secretion did not yield better results. These findings provide valuable insights into the effects of bacterial secretions and algae compost, separately, on both soil health and crop performance.

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GT 07 - 913 - P

BIOSTIMULANTS SPRAYED ON VEGETATIVE GROUNDCOVERS TO IMPROVE THE NITROGEN FERTILIZATION AND THE CARBON SEQUESTRATION IN OLIVE ORCHARD

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Groundcovers (GC) in woody crops represent an essential soil management to improve soil health. N fixation through vegetative GC, combined with specific biostimulants, can reduce dependence on synthetic fertilizers, and improve soil organic matter. The 'BioCover-Soil' project aims to evaluate sustainable strategies to enhance nitrogen fixation and carbon sequestration in olive groves through the application of two biostimulants (at a dose of 5L/ha) on the GC. One applied with the GC growing to maximize the biological fixation of N before the mechanical control; and the second applied after the mowing to improve the mineralization of the N whereas the C mineralization is minimized.

The study was carried out in two olive orchards; one located in the IFAPA (Andalusian Institute for Research and Training in Agriculture) experimental station, where a seeded GC of barley (50%) and hairy vetch (50%) was established at a dose of 100 kg/ha of orchard without irrigation; the other field is a commercial farm with spontaneous GC and drip irrigation. The evolution of soil cover provided by the GC along the season, the amount of biomass and its N content before the mechanical mowing were studied. Likewise, the soil was tested to 0-20 and 20-40 cm depth and the mineral N (NO3- and NH4+) and organic C analysed.

The degree of soil cover provided by the GC was lower in the first season (22/23) due to the lack of precipitation, which also affected the activity of the microorganisms of the biostimulants. In the second season (23/24), abundant rainfall during early spring allowed for significant GC development, providing high soil cover and biomass before the control. In the experimental station, the amount of N in the biomass (kgN/ha) in the second season was significantly higher with biostimulants than in the control. The mineral N in soil showed a decrease while the GC is absorbing during its development. After the control, the soil N was increasing as the residue is decomposed and N content in biomass is released. After the GC control and the spraying of the second biostimulants, the soil mineral N tend to be more available in the biostimulants treatment, although statistically significant differences were no observed. The soil organic C at tested soil depth increased in both treatments during the three seasons assessed. In the first season, the mean of the control treatment was higher without significant differences. However, in the third season, the trend changed, with the mean being higher with biostimulants. The change in the trend was already observed during the second season in the experimental station.

The fertilization strategy using biostimulants on the GC improves the N fixation and stabilizes soil C, enhancing the nutrients recycling and soil fertility. This a sustainable system suitable for organic agriculture.

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GT 07 - 915 - P

QUALITY OF ORGANIC FEEDSTOCK AND COCOA POD HUSK BIOCHAR CO-COMPOST IN SOUTHWEST NIGERIA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Crop production in Nigeria is constrained by soil infertility due to low organic matter. Compounding the problem is that nutrients lost through harvest are not replaced with fertilizer due to high cost and unavailability. Meanwhile, the agricultural sector is the major contributor of organic waste in the country. Therefore, composting will be a valuable way to convert organic waste into organic matter, thereby restoring soil fertility. This study aims to explore and estimate the rate of carbon and nitrogen transformation during composting of different organic feedstocks with or without cocoa pod husk biochar (CPHB). The experiment was set up as a split-plot design with feedstock as the main plot and biochar as the subplot. Four feedstocks, i.e., poultry manure (PM), broadleaves (BL), grasses (GR), and peels of Manihot esculenta Crantz (ME), were composted with biochar (BC) and without biochar, leading to eight treatments (PM, PM+BC, BL+PM, BL+PM+BC, GR+PM, GR+PM+BC, ME+PM, ME+PM+BC) replicated five times. The study showed that the average dry matter loss of BL+PM, GR+PM, and ME+PM was 32%, 31%, 47%, and 35% higher ($p < 0.01$) than PM on days 7, 14, 35, and 90, respectively. Similarly, the average N loss of other feedstocks was 21%, 24%, 29%, and 35% higher ($p < 0.01$) than PM on days 7, 14, 35, and 90, respectively. Compost without biochar had 17% higher ($p < 0.01$) dry matter loss than biochar-amended compost on day 90. Similarly, compost without biochar had 10% higher ($p < 0.05$) N loss and 9% higher ($p < 0.01$) N loss than biochar-amended compost on days 35 and 90, respectively. The average decomposition rate of the dry matter of the other feedstock was more than twice the rate of PM. The average N released rate of BL+PM and GR+PM was 45% more ($p < 0.01$) than that of PM. Biochar did not influence the decomposition rate of dry matter and N release. The study showed that other organic waste mineralized faster than PM. We conclude that compost amended with biochar retains higher nutrients compared to compost without biochar at maturity.

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GT 07 - 918 - P

EVALUATION OF THE AGRONOMIC POTENTIAL OF SEWAGE SLUDGE-DERIVED HYDROCHARS IN CONTRASTING SOIL TYPES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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This study evaluated the agronomic potential of a hydrochar produced by HTC of SS at 230 °C for 45 min, subjected to different post-treatments. Two contrasting soils were used: a calcareous sandy loam soil (pH 7.6; 12.7% $CaCO_3$; 1% organic matter; 16.1 mg kg^{-1} Olsen P, soil B) and an acidic loam soil (pH 4.5; 1% organic matter; 31.9 mg kg^{-1} Olsen P, soil Z). Each soil was amended with 3% (w/w) of (i) fresh hydrochar (FHC), (ii) water-washed hydrochar (WHC), or (iii) aged hydrochar (AHC, stored for two months in open air at room temperature). Unamended controls were also included. Soils were incubated for 6 weeks under controlled light, temperature, and moisture conditions. Porewater was sampled at weeks 2, 4, and 6 to analyze pH, dissolved organic carbon (DOC), nutrients, and potentially toxic elements. After incubation, soil samples were analyzed for chemical properties (pH, EC, total C and N, Olsen P, organic matter) and enzymatic activities (β-glucosidase, phosphatase, urease).

Results showed no pH change in soil B solution, but an increase in soil Z with FHC and AHC. Both treatments also raised DOC in both soils, while WHC caused a slight, non-significant increase. Soluble P increased in both soils, especially in soil Z with FHC and AHC, due to higher soluble P content in these materials. Soluble S increased significantly with FHC and AHC towards the end of incubation, while WHC caused an initial increase that declined over time. A significant rise in soluble Cu was also observed in both soils, likely related to DOC increases from all treatments.

Regarding soil chemical parameters, FHC lowered pH in soil B, while AHC raised pH in soil Z. All treatments increased organic matter in soil B but had no effect on soil Z. Olsen P only increased with AHC, while total C and N rose significantly with all treatments in both soils, with no differences among treatments. Urease and β-glucosidase activities were unaffected, while phosphatase increased in soil B with WHC but decreased in soil Z with AHC. These enzyme responses did not correlate with soluble or extractable P levels.

Overall, these results show that both fresh and aged hydrochar had greater effects on the analyzed parameters, highlighting the importance of testing these materials on soils with different characteristics, as their impacts can vary widely.

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GT 07 - 919 - P

THE STABILITY OF SOFTWOOD BIOCHARS AND THEIR IMPACT ON NITROGEN RETENTION IN CONTRASTING BOREAL SOILS OVER 14 YEARS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Biochars as soil amendments have been reported to fix carbon and, in some cases, also improve soil ammonium (NH4+) and nitrate (NO3-) retention. However, biochar added to fields undergoes physicochemical changes and spatial migration under long-term environmental influences. Knowledge gaps remain regarding how biochar's nitrogen retention capacity changes over time and its migration patterns in the soil profile. We targeted these gaps by studying two long-term biochar field experiments in Finland where biochar was applied to soils (Stagnosol and Umbrisol) in 2010 and 2011, respectively.

Firstly, we studied whether biochar was moving downwards in the soil profiles, from the 0-10 cm depth where it was originally applied to, and whether this movement was related to the soil type. Secondly, we tested whether the migrated biochar contents could explain N (especially NO3-) contents across the soil profiles, and thus provide NO3- retention capacity even in deeper soil layers long time after soil biochar soil application. We analyzed soil samples collected from 0–50 cm depth, and divided these into 10 cm deep layers for analysis.

Results showed that in the Stagnosol field, significant differences in NO3- retention were observed between biochar-treated and control samples at 10–20 cm depth, demonstrating that biochar's effect on NO3- retention persisted 14 years after application. Further characterization of biochar content and properties using benzene polycarboxylic acid (BPCA) molecular markers revealed that biochar remained present in soil after 14 years. NO3- concentrations were clearly correlated with the BPCA contents throughout the Stagnosol soil profile (R^2=0.58), while the correlation between BPCA contents and NH4+ concentrations was less strong (R^2=0.24). In contrast, biochar addition showed minimal long-term effects on NO3- and NH4+ retention in Umbrisol field. In both fields, black carbon exhibited a downward leaching trend after 14 years. Downward movement of biochar was significantly greater in the Stagnosol than in the Umbrisol ($p < 0.05$). However, in total less of the applied biochar was remaining in the Umbrisol soil than in the Stagnosol soil. This difference may be attributed to the nutrient-poor status of the Umbrisol soil, which could have promoted enhanced microbial activity upon biochar addition. The fresh carbon inputs stimulating microbial decomposition would result in greater biochar loss via decomposition in the Umbrisol compared to the Stagnosol soil. The study demonstrates that biochar can be preserved long-term in soil while maintaining NO3- retention capacity, reducing nitrogen loss, which has important implications for sustainable nitrogen fertilizer management.



GT 07 - 923 - P

BIODEGRADATION OF GRAPEVINE STALKS: ITS USE AS AN AMENDMENT TO MITIGATE CU AVAILABILITY IN VITICULTURAL SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Mitigating Cu toxicity through soil conditioning can give place to the use of industries' end-of-waste products, fostering the circular economy in favour of the environment. Thus, considering the valuable wastes generated in grape production and vinification, a possible remediation strategy for Cu accumulation may lie within the viticultural practice itself. Looking at grape stalks, a significant waste from the vinification process which, unlike other subproducts, are not broadly valorised, this work studied their role as a potential soil amendment for reducing Cu toxicity after their biodegradation using saprophytic fungi. Soil saprophytic fungi, which include white-rot fungi (WRF), are essential for the carbon cycle through the degradation of lignin and other complex polysaccharides. Since grape stalks are rich in lignin, taking advantage of these species will allow for a cost-effective biodegradation of this product.

As a first step, grape stalks were subjected to solid-state fermentation (SSF) using different WRF species to identify the most effective ones. Thus, a comprehensive assay with nine WRF species (Ganoderma linghzii, Ganoderma lucidum, Lentinula edodes, Phlebia rufa, Pholiota nameko, Pleurotus eryngii, Pleurotus ostreatus, Pleurotus pulmonarius and Trametes versicolor) and different time points for sample collection was performed, to assess grape stalks' degradation profiles of each WRF species. SSF was held for 8 weeks, with harvesting at 0, 4 and 8 weeks. Dry weight loss and quantification of lignin contents of the product of SSF were used as a monitoring tool to assess the degree of degradation of grape stalks. A significant reduction of grape stalks' dry weight of around 30% was achieved by three of the tested species (T. versicolor > G. lucidum > L. edodes).

Based on the results concerning the biodegradation capacity of grape stalks, the final products obtained from the selected species will be used in future studies, including their application as a soil amendment. For this, viticultural soils from the Douro Demarcated Region will be used, which are actively receiving Cu inputs coming from organic disease management. The available Cu will be quantified in samples of the soil pore water to understand the role of the grape stalks' degradation product in reducing Cu availability in soil.

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GT 07 - 927 - P

POULTRY FEATHER HYDROLYSATE AS A SUSTAINABLE SOIL AMENDMENT: ENHANCING SOIL FERTILITY AND WHEAT GROWTH IN COARSE-TEXTURED SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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The sustainable management of agricultural soils necessitates innovative amendments that enhance fertility and promote plant growth. Poultry feather hydrolysate (PFH), a nutrient-rich biostimulant, offers a promising solution. Despite its potential, the effectiveness of PFH applied directly to soil, particularly concerning varying addition rates and physical states across different soil textures, remains underexplored. This research, encompassing both microcosm and controlled pot experiments, investigated the effects of PFH applied in liquid and solid states at various addition rates (0, 4, or 8 t dw ha-1) on microbial activity, nutrient dynamics, and organic matter (OM) stabilization in coarse-textured soils through a six-month microcosm study. Concurrently, a three-month pot experiment assessed identical PFH applications on wheat (Triticum aestivum L.) biomass growth and soil properties. The microcosm study showed that sandy loam soil responded more strongly to PFH than loamy sand soil, supporting 20% higher microbial activity, 35% greater nutrient retention, and 89% enhanced OM stabilization. Liquid PFH promoted prolonged microbial activity and sustained nutrient release, increasing soil nutrient content by 106% at the high rate. The pot experiment revealed that PFH consistently increased wheat shoot and root biomass by up to 109% and 74%, respectively. High PFH addition rates also significantly improved soil OM content (20%) and water-holding capacity (9%). While liquid PFH stimulated rapid crop biomass growth and microbial activity, the solid state provided more sustained effects. Overall, this research demonstrates that PFH, especially in liquid state and at higher rates, effectively enhances soil health indicators (microbial activity, nutrient availability, OM stabilization) and boost crop productivity, while the solid state contribute to offer long-term benefits . This study thus highlights PFH's potential as an effective, sustainable soil amendment, with application strategy and soil texture playing critical roles in maximizing its agronomic and environmental benefits.



GT 07 - 931 - P

VALORISATION OF ORGANIC WASTE STREAMS FOR THE REHABILITATION OF DEGRADED SOILS: A MESOCOSM-BASED ASSESMENT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Unsustainable soil management accounts for 60–70% of soil degradation in the EU [1]. Soils provide critical ecosystem services, yet increasing global food demands will require enhancing soil productivity by up to 100% in developing countries by 2050. Simultaneously, the continuous rise in waste generation [2] underscores the urgent need for sustainable and circular waste management strategies.

In this context, COGERSA, the public waste management company of Asturias (NW Spain), has implemented advanced treatment technologies such as Mechanical-Biological Treatment (MBT) and anaerobic digestion to improve resource efficiency and reduce landfill use. These processes generate significant volumes of organic by-products and biowastes, which, due to their composition, show promising potential as soil amendments for the rehabilitation of degraded or contaminated soils, including mining areas – contributing to EU sustainability and circular economy goals.

To evaluate the feasibility of these waste-derived materials as soil amendments or as potential technosols, a controlled mesocosm experiment was established using eight 1 m3 Intermediate Bulk Containers (IBCs). Each was filled with a mixture of fine aggregates (<20 mm) obtained from the recycling of construction and demolition wastes (CDWs) and various organic amendments at an 80:20 ratio. The amendments tested included: green compost, treated sewage sludge by composting, compost of the digestate of municipal biowaste separately collected, bio-stabilised organic matter from mixed municipal waste, commercial compost, and topsoil. Two control treatments –100% CDWs and 100% composted sewage sludge– were also included. Rhyzons and a suction plate were installed at different depths to collect leachates, and typical native vegetation was planted.

The raw materials were initially characterised for general properties, total and available metal(oid)s, total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAHs). Bimonthly sampling is being conducted over a six-month period, with periodic analysis of leachates to ensure compliance with environmental regulations and assess potential risks associated with the use of these materials. Monitoring likewise includes organic carbon fractionation to evaluate soil carbon sink capacity, enzymatic activities (β-glucosidase, alkaline phosphatase, and urease); biomass productivity, metal(oid)s contents in vegetation and photosynthetic efficiency are also assessed.

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GT 07 - 932 - P

FERTILIZATION MANAGEMENT MAKES SIGNIFICANT DIFFERENCES IN THE SOIL OF AN URBAN GARDEN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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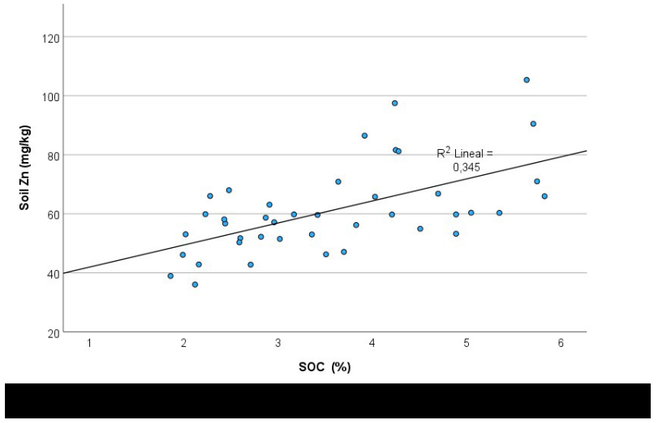
One type of urban garden consists of small plots (~100 m²) individually managed by different gardeners. Each gardener, following their own practices, carries out soil management and fertilization—typically using organic amendments. This individual approach may eventually lead to variability in the elemental composition among plots. In this study, portable X-ray fluorescence (pXRF) was used to assess the elemental composition of soil from different plots within an urban garden located in the Quinto Centenario Park in the municipality of Utrera, province of Seville (37.19507, -5.76584), which has undergone continuous manure fertilization over a 13-year period.

The results show substantial inter-plot differences in the concentrations of S, Zn, Ca, and P, with maximum-to-minimum concentration ratios of 11.5, 6.8, 6.1, and 4.5, respectively. Other properties, such as soil organic carbon (SOC) and carbonate content, also exhibited broad variation ranges (14.6–59.9 g kg^{-1} for SOC and 14.6–292 g kg^{-1} for calcium carbonate). Correlation analysis between elemental concentrations and SOC, as well as factor analysis, revealed significant relationships between SOC and the concentrations of Zn, total and available P, total and available Ca, and calcium carbonate content. These findings suggest that differences in the quantity and/or type of manure applied by individual gardeners are responsible for the observed variability.

Other elements such as Cu also showed high variability and elevated levels compared to the site’s native soil, likely due to frequent use of copper-based fungicides. In contrast, intra-plot variability for these parameters was much lower, underscoring the influence of individual management. Compared to the native soil, a notable increase in SOC was also observed, indicating net carbon sequestration. Although heavy metal concentrations remain well below levels considered hazardous in soils, the intensive use of manure warrants continued monitoring.

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Soil Zn content vs SOC content



GT 07 - 935 - P

EFFECT OF CONVENTIONAL AND INHIBITOR-TREATED UREA APPLICATION ON NH3 EMISSIONS FROM SANDY SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Fertilizer management in intensive agriculture contributes to ammonia (NH3) emissions from soils. NH3 is a major air pollutant mainly originating from the agricultural sector that causes several environmental problems and troubles for human health; therefore, investigating mitigating methods is essential for future policy making.

In this study, we investigated the impact of conventional urea and urea with urease inhibitor fertilization management on NH3 emission of sandy soil. The experiments were conducted at three different levels: a laboratory setting, an open-air mesocosm experiment, and a field trial. In the laboratory experiments, we used 12 cm high small containers with a 30 cm x 30 cm surface. Lower and higher doses (150 and 180 kg N ha-1) of conventional urea and inhibitor-treated urea were applied with the broadcasting method to bare soil surfaces, and the same doses were also applied with the incorporation method with conventional urea. In the mesocosm experiment, we used 85-liter containers (d = 53 cm, h= 45cm) placed in the open air. In the first year, the same doses of urea and treated urea that were used in the laboratory experiment were applied using the broadcasting method, and one maize per container were cropped. In the second year, triticale was sown in the containers, and the higher and lower doses were adjusted to 150 and 120 kg N ha-1, depending on crop demand. The field investigations were conducted during two consecutive years, from 2021, under triticale cropping with the same treatments as in the mesocosm experiment of the second year. NH3 measurements were carried out with the static chamber method using the Picarro G2103 device, and soil temperature and soil moisture were also measured as auxiliary parameters.

The results showed that incorporation was the most effective method for reducing NH3 emissions, while higher doses of broadcasted urea led to increased emissions in the laboratory, regardless of whether conventional or inhibitor-treated urea was used. In the mesocosm experiment, under maize cropping, the use of inhibitors reduced NH3 emission by 52% and 27 % for the 180 and 150 kg N ha-1 doses, respectively, compared to conventional urea. No differences were found between the emissions under triticale cropping. That means that the urease inhibitor was only effective in mitigating under maize cropping when the climate was warmer. In the field experiment, NH3 emission increased in all treatments after urea application, but the increase was lower when inhibitor was also used. This experiment highlights the importance of the application method of urea and the possible use of inhibitors, although the intra-annual variation in the NH3 results is also important to note.

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GT 07 - 938 - P

SOIL NITROGEN CYCLING AND MICROBIAL ACTIVITY ENHANCED BY MANURE FROM CARBON-ENRICHED CATTLE BEDDING

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Prolonged retention of cattle bedding in stables increases the risk of greenhouse gases and ammonia emissions, coupled with undesirable nutrient losses from litter used for manure production. The addition of amendments based on stabilized organic carbon to cattle bedding offers several health and welfare benefits to animals, including reduced moisture, improved hoof hygiene, and lower infection rates. Moreover, it enhances nutrient retention in the litter, notably by reducing nitrogen volatilization in the form of ammonia. Consequently, improved nutrient retention in bedding and excreta enables the production of manure of superior quality, with presumably enhanced fertilizing and soil-conditioning potential.

These hypotheses were tested in a 30-day stable experiment with cows (groups of eight animals), housed in boxes which bedding amended with i) agricultural-waste biochar, ii) a humic-rich derivate of leonardite (commercial product Humac), and iii) a combination of both amendments. Manure from the combined biochar + Humac treatment had significantly higher total carbon content, while manure from the biochar-only treated had significantly increased total nitrogen and phosphorus contents compared to manure from the control group (from bedding without amendments). All treatments increased the pH of manure relative to the control.

The impact of these manures on soil was evaluated in a 12-week pot experiment with maize (Zea mays L.). Soil amendment with manure derived from the biochar+Humac bedding showed reduced basal respiration (BR) and enhanced microbial potential to utilize nitrogen sources, as indicated by increased respiration induced by N-rich substrate (L-arginine) compared to manure control the control and Humac-only treatments.

In conclusion, the tested bedding amendments in cattle husbandry significant improved nutrient retention (carbon, nitrogen, phosphorus) in the resulting manure. The enhanced manure quality also positively influenced the soil´s capacity to utilize nitrogen.

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GT 07 - 952 - P

PRACTICAL SOLUTIONS TO REVERSE SOIL DEGRADATION BY USING ORGANIC AMENDMENTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Soil plays a fundamental role in sustaining ecosystem functions and services, including food production, regulation of water and nutrient cycles, and climate change mitigation. However, several human activities, such as mining, pose significant threats through soil contamination. Therefore, the restoration of degraded soils has become a key challenge in ensuring food security, preserving biodiversity, and addressing climate change. Among the most promising strategies, organic amendments derived from residual biomass offer a sustainable approach to enhance soil quality and promote ecological recovery.

This study investigates the effectiveness of two different organic amendments (hydrochar and compost) in improving the biogeochemical properties of a heavy metal-contaminated soil from the disused Mónica mine (Madrid, Spain). Hydrochar was produced by hydrothermal carbonization of vegetation waste, and compost was generated by composting urban pruning waste.

A pot experiment was conducted including three treatments: soil + hydrochar (SH), soil + compost (SC), and unmodified soil (S), with two exposure times (t0 and t60 days). Both amendments were applied to the soil at an equal rate of 92.4 g kg^{-1}.

Preliminary results at t60 indicate that both amendments significantly increased water content capacity (WHC), pH and organic carbon (Corg) compared to the control. Specifically, pH increased by 14.9% and 8.42% and Corg rose by 36.7% and 34.9% in SH and SC, respectively. Microbial carbon (Cmic) was significantly higher in SC compared to S and SH, while the observed general increase in soil respiration (R) suggested an activation of microbial communities over time. In addition, further analyses currently underway, targeting soil carbon fractions, enzymatic activities, germination assays, and potential toxic elements mobility and bioavailability, will provide a more comprehensive understanding of the effects of amendments on the recovery trajectory of this degraded soil.

These findings underscore the potential of biomass-derived organic amendments as an effective and sustainable strategy to restore the soil-plant-microbe system of contaminated soils under a circular economy framework.

GT 07 - 959 - P

REDUCTION OF NET GLOBAL WARMING POTENTIAL THROUGH CROP ROTATION PRACTICES IN ORGANIC FARMING SYSTEMS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Reducing greenhouse gas (GHG) emissions while concurrently enhancing soil organic carbon (SOC) is a contemporary challenge in agricultural sectors, and crop rotation system is an important management to improve soil fertility and environmental sustainability. However, the annual evaluation of net global warming potential (net GWP) has not been well explored under crop rotation systems. The present study explores the potential to increase SOC stocks while reducing net GWP under different cropping system; (1) monocropping with inorganic fertilizer(MF), (2) monocropping with compost(MC), (3) maize–hairy vetch–soybean with compost(RVB), (4) maize–Chinese cabbage–rye with compost(RCR), based on a 10 years of organic experimental field

The emission rates of three gases were simultaneously monitored once a week using the closed-chamber method. Especially the net ecosystem C budget (NECB), which refers net exchanges of CO_2, was measured for the total rate of organic carbon accumulation in or loss from ecosystems. The net GWPs, which was calculated as CO_2 equivalents by multiplying the seasonal GHG fluxes, minus soil organic carbon (SOC) changes derived from the NECB, were compared.

Our results showed that legume inclusion led to higher SOC stock (52% on average) than maize single cropping, but the highest NECB value was observed in RCR plot. The yields of main cash crop, maize, were not significantly different among the treatments. The total GWP of MF was 2 times higher than other treatments, mainly due to the great amount of N_2O flux during cropping season. Cultivation of cover crops such as hairy vetch and rye significantly decreased the N_2O emission during fallow season, which led the overall reduction of annual GWP value in crop rotation systems. The study highlights the impact of cover crop inclusion on year-round nutrient cycling and biological nitrogen use efficiency which mitigated global warming and increased SOC stock in organic farming systems.

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GT 07 - 971 - P

ORGANIC AMENDMENTS PROMOTE BETA-PROTEOBACTERIAL NITRIFIERS IN SEMI-ARID MINE SOIL AFTER 40 MONTHS OF RESTORATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil degradation in semi-arid regions severely limits productivity and ecosystem function, particularly in post-mining landscapes. Organic amendments are a promising strategy to promote soil fertility and microbial activity, supporting nutrient cycling during soil restoration [1,2]. Our previous results showed that restoration significantly improved nutrient content (TOC, TN, AP) and nitrogen fractions[3]. Here, we provide a solid basis for these shifts by analysing functional microbial groups driving N turnover.

We evaluated the functional and taxonomic responses of soil bacterial communities to six organic amendments after 40 months of field restoration in a limestone mine soil in Almería (Spain). Treatments included compost from greenhouse crops (CC), compost from garden pruning waste (CG), stabilized sewage sludge (SS), and their mixtures (MIX1 = CG+SS; MIX2 = CC+SS), along with a non-amended control (CON) and natural reference soils (NAT). Short-read shotgun metagenomic sequencing (Illumina) was used to assess microbial communities and quantify the functional potential of 24 microbial functional groups driving key processes of N turnover using the SqueezeMeta pipeline (v1.6.5). Statistical analysis and visualizations were performed with RStudio (v. 4.3.1).

Microbes involved in assimilatory (e.g., nasB, narB) and dissimilatory nitrate reduction processes (e.g., narGHYZ, narIJVW, nfrA) showed the highest overall abundance, alongside the denitrification genes (e.g., nirK, norB, nosZ), in amended soils compared with CON soils, although still not reaching the NAT state. Restored soils showed a proliferation of Alphaproteobacteria, Betaproteobacteria, Gammaproteobacteria, and Cytophagia classes, as well as an increase in the abundance and diversity of microbes catalyzing major processes of inorganic N turnover in comparison with untreated soils. Interestingly, SS-treated soils and their mixtures showed a promotion of Betaproteobacteria involved in nitrification procesesses (e.g., amoABC, hao). Conversely, compost treatments also benefited N turnover, although with slight changes compared to NAT soils. Random forest analysis revealed that these total shifts strongly influenced dissolved N and nitrate concentrations.

Overall, our results indicate that organic amendments increased the abundance of microbes involved in key pathways of N transformation, favouring soil microbial functionality of degraded soils in arid environments. Our results support the use of organic amendments to restore soil ecological processes and promote medium-term sustainability in post-mining landscapes.

ACKNOWLEDGEMENTS

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Linking functional nitrogen cycling genes to soil bacterial taxa at the class level across treatments.

GT 07 - 977 - P

TECHNOSOLS FROM RIVER DREDGED SEDIMENTS AND GREEN COMPOST IMPROVE SOIL PROPERTIES AND WHEAT YIELD IN THE GUADALQUIVIR BASIN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Large quantities of dredged riverine sediments are generated annually, highlighting the need for sustainable valorization strategies. Previous studies have demonstrated that incorporating dredged sediments into agricultural soils can enhance crop yields and plant quality [1]. However, concerns remain regarding potential reductions in soil phosphorus (P) content, particularly in cases of partial soil replacement with these materials. The Guadalquivir marshlands are characterized by fine-textured, compacted soils with low organic matter content. The application of organic amendments, such as plant-derived compost, can help mitigate these limitations by improving soil structure, enhancing nutrient cycling, and offering an environmentally sound strategy for managing surplus biomass [2].

In light of these challenges, this study evaluated during 6 months the potential of combining river dredged sediments with plant-based compost to improve soil health and crop productivity in agricultural areas of the Guadalquivir basin, near the river’s drainage zone. Two technosols were formulated by mixing native soil with two types of river dredged sediments and green compost. Compost was included in the mixtures to increase nutrient availability, given its high phosphorus content. Three soil sampling campaigns were conducted to monitor changes in the physical and chemical properties of the soils. A wheat crop was harvested in June 2025 to assess agronomic performance.

The technosols exhibited lower compaction than control soils, as evidenced by reduced bulk density and penetration resistance. Soil respiration rates were initially higher in the technosols, although this effect diminished over time. The combined application of dredged sediments and compost positively influenced crop performance, resulting in a greater number of grains per wheat head and higher individual grain weight. However, total plant biomass and grain protein content were comparable among treatments.

Overall, these results indicate that dredged sediments, when properly combined with organic amendments, can serve as effective soil conditioners in agricultural systems. The observed agronomic and soil responses were comparable to, or exceeded, those obtained with conventional fertilization practices.

ACKNOWLEDGEMENTS

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GT 07 - 978 - P

APPLICATION AND VALIDATION OF ROCK-EVAL® RAMPED THERMAL ANALYSIS TO BIOMASS-BASED PRODUCTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The return of biomass to the soil in agriculture is a major challenge for maintaining soil fertility while playing a crucial role in carbon storage. These biomasses, amendments or organic fertilizers, of varied and often heterogeneous origin, are characterized by different fertilizing and amending values. The characterization of the agronomic potential of these materials is necessary to optimize their contributions to soil and plants. The indicator of residual organic carbon (IROC), obtained by a biochemical fractionation (Standard XP U44-162) and an incubation (Standard XP U44-163), is the reference for determining their agronomic potential. However, IROC is based on a long, expensive and highly solvent-consuming analytical protocol, which limits its accessibility to farmers. In response to this need, the Rock-Eval® (RE) method, based on a ramped thermal analysis method allowing a quantitative and qualitative characterization of carbon, could represent an alternative. Indeed, the efficiency of the analytical technique has been recognized for soil characterization (standards ISO 23400/2021 and ISO/CD TS 21251) but has only recently been considered for the study of biomass and or product issued from them.

The objective of the present study is to adapt the RE method to biomass. We analyzed 32 biomass samples of different origins, that may or not been altered with various processes (methanization, pyrolysis, composting, etc.). They were divided into six categories according to their origin and presumed biodegradability: "Wood", "Non-wood," "Slightly altered," "Biologically altered", "Thermal altered", and "Other organic residual" biomasses.

Firstly, we optimized the RE method specifically to the study of "biomass" samples. To achieve this, certain analytical parameters (sample mass, heating rate) were adjusted for biomass characterization with RE.

Once the RE protocol was set up, it was applied to characterize the 32 biomass samples. The accuracy of carbon quantification with our new RE method was validated by comparing RE carbon content with those obtained using elemental analysis. Globally, the correlation is good however, some recommendations will be given depending on the origin and type of biomass. A statistical approach was used to demonstrate the repeatability of RE analysis of data using replicates, and to tentatively infer specific carbon properties using RE parameters such as HI, OI, I, R to categorize our samples. While some categories, such as thermally altered biomass, can be easily discriminated using specific RE parameters, others are more challenging.

Work is currently underway to clarify the robustness of the RE method for biomass samples by better considering their source properties. Several corrections are being explored to improve carbon quantification. Additionally, new parameters are being proposed to enhance the categorization of biomasses and to better reflect their biological stability.

GT 07 - 979 - P

SOIL RESPIRATION UNDER TREATMENTS WITH DIFFERENT SEAWEED FORMULATIONS AND BYPRODUCTS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Using seaweed has a long tradition in agriculture, particularly in coastal regions, due to its rich content of organic matter, essential nutrients, and naturally occurring plant hormones. Among brown seaweeds, Ascophyllum nodosum is widely used in fertilizer production, primarily because of its high concentration of bioactive compounds that promote plant growth, enhance root development, and increase resistance to environmental stress. However, concerns over the sustainability of large-scale seaweed harvesting have led to increased interest in the reuse of processing by-products. Repurposing these residual materials not only supports waste reduction and resource efficiency but also offers a promising approach to improving soil quality and contributing to carbon sequestration.

The current study explores the effects of two different by-products (AF and Asco residue) derived from seaweed-based fertilizer production on soil respiration, an important indicator of microbial activity and soil health. The experiment was conducted on four soil types—two from Croatia and two from Estonia—using two application rates: 2% and 4%.

As anticipated, higher application rates (4%) led to increased soil respiration across all samples, regardless of the type of seaweed residue. Soils with a higher organic matter content also exhibited more intense respiration, likely due to elevated microbial activity and the enhanced breakdown of labile compounds present in the seaweed materials. After 7 to 10 days, the soil respiration of soils amended with byproducts reach equilibrium, and there is no significant difference between the respiration of the control soil and soils amended with seaweed.

When examining the 2% application rate across all soil types, a significantly higher respiration rate was observed in soils treated with the AF byproduct, a finer material resulting from chemical extraction, compared to the coarser Asco residue byproduct. This suggests that particle size and processing method may influence microbial accessibility and decomposition rates. Interestingly, at the higher dosage (4%), the difference between the two by-products disappeared, indicating that microbial communities may have reached a saturation point in their activity, regardless of the material's physical characteristics.

These findings highlight the potential of seaweed processing by-products as soil amendments, with their effects influenced by both soil properties and application rates. Further research could investigate long-term impacts and potential synergies with other organic amendments.

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INDEX

GT 07 - 980 - P

EFFECT OF HYDROXYAPATITE NANOPARTICLES ON THE GERMINATION AND EARLY DEVELOPMENT OF TRITICUM AESTIVUM AND CHENOPODIUM QUINOA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Hydroxyapatite is a compound with emerging applications in sustainable agriculture, acting as a controlled-release fertilizer and a soil amendment. In this study, hydroxyapatite nanoparticles (NPHA) were synthesized and applied in phytotoxicity assays to evaluate their effect on germination and early growth in two crops of agri-food interest: wheat (Triticum aestivum) and quinoa (Chenopodium quinoa). The assays were conducted under controlled conditions, both in aqueous solution and agricultural soils. The doses tested were 0, 7.5, 15, 30, 60 and 120 kg ha-1, and parameters such as germination percentage (G (%)), germination index (Gindex (%)), and aerial part index (APindex (%)) were evaluated. The pH of the NPHA solutions ranged from 5.8 to 7.1. Soil S1 had slightly acidic pH (5.6), high organic matter content (12.5%), and loam texture; S2 has neutral pH (6.6), with lower organic matter content (2.9%) and sandy loam texture.

The results for wheat showed high sensitivity to the applied dose and exposure medium. When applied in solution, NPHA maintained high germination rates (≥ 93.3%) across all doses but negatively affected growth, showing inhibition in all cases (with minimum Gindex of 50.2% and APindex of 57.4%). In soil S1, the overall effect was stimulatory, as expected. G increased in all cases, reaching up to 80% after 7 days, and stimulation was observed in nearly all cases for Gindex and APindex, with values of up to 154.8% and 190.8%, respectively, at 120 kg ha-1 after 3 days. In S2, a more variable response was observed, generally inhibitory, although stimulation was recorded at 15 kg ha-1after 3 days.

In quinoa, the effects were stimulatory in solution, although germination was lower than in wheat (63–80%). Gindex reached a maximum of 617.9% and APindex 262.6% at 30 kg ha-1at the end of the incubation period. In S1, Gindex ranged from 70% to 87%. Positive responses were recorded for Gindex and APindex, especially at higher doses. In S2, G generally decreased as the applied dose increased. Inhibitory effects on growth were observed at all doses. These negative results in S2 for both plants may be due to low NPHA solubility at higher pH, limiting nutrient availability for seed development and growth.

These findings highlight the potential of NPHA as a soil amendment or biostimulant, especially in soils with higher organic matter content due to their buffering capacity. However, the effectiveness of these nanoagrochemicals depends on factors such as crop species, applied dose, and soil properties, which must be carefully considered to avoid phytotoxic effects and maximize their potential as a tool in sustainable agriculture.

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GT 07 - 998 - P

OPTIMIZING SOIL ORGANIC AMENDMENTS FOR SUSTAINABLE VEGETABLE PRODUCTION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Vegetable production is an intensive farming system that relies heavily on fertilizers, frequent tillage, and pesticides to achieve high yields, practices that can degrade soil health by accelerating the loss of soil organic matter. With around 60% of EU soils classified as unhealthy, largely due to declining soil organic carbon (SOC), soil degradation poses a significant threat to food production. Coupled with growing food demand, this underscores the need for strategies that improve soil health while sustaining intensive vegetable cultivation. One promising approach is the use of organic bioresidues, which can enhance soil structure, stimulate microbial activity, and increase SOC. However, their slow nutrient release, especially of nitrogen (N), often limits crop productivity.

This study investigated a nutrient management strategy that integrates slow N-releasing bioresidues: compost (Cp), insect frass (IF), biofiber from anaerobic digestate (BF), and biochar (BC) with targeted fast-releasing N sources to synchronize nutrient availability and utilize waste-derived resources without compromising yields or soil health. A greenhouse pot experiment with lettuce (Lactuca sativa L.) grown in sandy soil evaluated 12 treatments, including three controls (no fertilizer, organic, and mineral fertilizers). The four bioresidues were applied alone at feasible rates but did not meet the crop's N requirement of 155 kg N ha^{-1}, thus, fast-releasing N sources were used to compensate. The compensated treatments included compost with liquid N from composting (CP_Liq), insect frass with liquid N (IF_liq), biofiber combined with liquid digestate (BF_dig), and biochar supplemented with either organic fertilizer (BC_OF) or insect frass (BC_IF).

Results showed that combining slow-releasing bioresidues with fast-releasing N sources (notably IF_liq and BC_IF) maintained fresh biomass similar to mineral fertilizer control, and exceeded organic fertilizer control. CP_liq and BF_dig showed similar fresh biomass as the organic control. These combinations also enhanced total nutrient uptake and achieved nitrogen use efficiencies (NUE) similar to the organically fertilized control. In contrast, treatments without N compensation showed N limitation, evident in lower yields, higher root-to-shoot ratios, and increased dry matter content. Microbial activity, measured as dehydrogenase activity, showed no significant differences, likely due to high variability. Compensated treatments generally left lower residual soil mineral N at harvest, suggesting better N synchronization and reduced environmental risks. Overall, the findings indicate that combining bioresidues with fast-releasing N sources can sustain vegetable yields while promoting more sustainable nutrient management and soil health under both organic and conventional systems.

ACKNOWLEDGEMENTS

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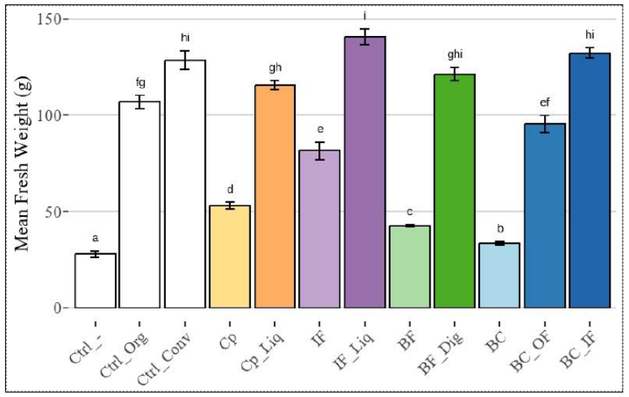


Figure 1: Lettuce fresh weight (FW) per pot (g) across 12 treatments (n = 5 pots per treatment). Bars represent treatment means, and vertical lines indicate standard error of the mean (± SE). Different letters above bars indicate statistically significant differences between treatments based on a one-way ANOVA on log-transformed data followed by Tukey's HSD post-hoc test ($\alpha = 0.05$).



GT 07 - 1001 - P

CHARACTERIZATION OF BIOCHARS FROM FRESH AND REUSED MISCANTHUS HORTICULTURAL SUBSTRATE FOR AGRICULTURAL USE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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In Germany, 8.5 million m³ of peat are used annually as horticultural substrate, emitting 1.0 million tons of CO_2 equivalent. Miscanthus giganteus grows well in diverse soils and climates and can successfully substitute peat, thereby mitigating this problem. Additionally, miscanthus has been recognised as a valuable feedstock for biochar production. Nevertheless, the agronomic potential of biochar produced from miscanthus sequentially used as greenhouse substrate remains unstudied. This study aimed to identify targeted agricultural applications for such biochars by investigating their elemental composition, particle-size, and 13C-NMR structural characteristics. Three biochars were characterized: biochar produced from fresh miscanthus (Bfm), from miscanthus used one time (Bum1x) and two times (Bum2x) as tomato substrate in greenhouse. The biochars were produced in a muffle furnace at 600 °C and 10 min residence time. Results are displayed in Table 1. The pH was similar across biochars (9.0 to 9.1). The yield of Bfm and Bum1x was about 2.4-times greater compared to Bum2x. The ash content (%) in Bum1x and Bum2x was about 2.8- and 2.1-fold greater than in Bfm (10.1%), respectively. Compared to Bfm, the element content in Bum1x and Bum2x increased (+) or decreased (-) as follows P: +709% and +378%, K: -13% and +40%, Ca: +2,377% and +2,037%, Mg: +426% and +657%, Na: +504% and +1,118%, S: +12,733% and +17,678%, Al: +366% and +327%, Si: +13% and -2%. The C/N ratio was higher in Bfm (274) than in Bum1x (46) and Bum2x (64). The aryl-C group dominated the 13C-NMR spectra of Bfm (81%), Bum1x (61%) and Bum2x (73%). The carboxyl-C contribution in Bum1x (8.1%) and Bum2x (4.5%) was 3.6- and 2.0-fold greater than in Bfm, respectively. The 13C-NMR-aromaticity index of Bfm (12.9) was 3.3- and 1.6-fold higher than that of Bum1x and Bum2x, respectively. The Bum1x and Bum2x exhibited most particles with diameter <2mm (66-77%) and between 4-2 mm (29-30%). Conversely, Bfm exhibited larger particles: 4-2 mm (42%), <2 mm (39%), and 8-4 mm (13%). In general, compared to Bfm, Bum1x and Bum2x were: 1) enriched with nutrients, likely due to the presence of residual fertilizer; and 2) exhibit greater functionalization and lower particle's size, probably due to the partial decomposition and fragmentation of their respective feedstocks during tomato cultivation. Overall, Bum1x and Bum2x may be a better amendment for improving soil/substrate fertility and nutrient retention, but Bum2x's low yield limits its scalability. On the other hand, Bfm may be better for soil C sequestration due to its higher C content and stability. Particularly, Bum1x is proximate to Bum2x in terms of particle-size and nutrient status, while being more functionalized and exhibiting similar yield in relation to Bfm. Therefore, in addition to Bfm, Bum1x emerges as a valuable product more viable to up-scaling compared to Bum2x.

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Attribute	Bfm	Bum1x	Bum2x
pH	9.0	9.1	9.0
Yield (kg kg^{-1}, dry %)	27.7	29.6	11.9
Ash (815 °C) (%)	10.1	28.2	21.4
C (%)	82.3	64.7	70.8
N (%)	0.3	1.4	1.1
H (%)	1.7	1.4	1.7
^{13}C-NMR Aromaticity index*	12.9	3.6	8.2
P (g kg^{-1})	3.0	24.4	14.4
K (g kg^{-1})	15.1	13.1	21.2
Ca (g kg^{-1})	2.4	59.2	51.1
Mg (g kg^{-1})	1.0	5.4	7.8
Na (g kg^{-1})	0.2	1.1	2.2
S (g kg^{-1})	0.1	7.7	10.7
Particle diameter >8 mm (%)	5	0	0
Particle diameter 8-4 mm (%)	13	1	4
Particle diameter 4-2 mm (%)	43	29	30
Particle diameter <2 mm (%)	39	70	66

*aromaticity index (aryl-C/(O-alkyl-C+alkyl-C))

Table 1. Average (n = 2 or 3) values of chemical, physical and structural attributes of biochar produced from fresh m iscanthus (Bfm), from miscanthus used one time (Bum1x) and two times (Bum2x) as tomato substrate in greenhouse.

GT 07 - 1017 - P

EFFECTS OF INCORPORATING VICIA SATIVA L. GREEN MANURE INTO SOIL ON N AVAILABILITY AND PRODUCTIVITY OF SOLANUM LYCOPERSICUM L.

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The environmental impact of chemical fertilizers, particularly groundwater contamination by nitrates, is well-documented. This problem is particularly acute in karst soils, such as those in the Mediterranean basin, highlighting the need for agroecological alternatives. One promising strategy is biological nitrogen fixation through leguminous cover crops, which has gained relevance due to rising fertilizer costs and new regulatory restrictions. This study assesses the application of common vetch (Vicia sativa) as a green manure to enhance soil fertility and promote tomato (Solanum lycopersicum) growth under Mediterranean field conditions. The experiment was carried out in Mallorca (Spain), where half of the plot was sown with vetch in the autumn, while the other half was allowed to develop a spontaneous mulch. Both covers were incorporated into the soil before tomato transplanting in spring. Soil nitrogen content, plant biomass, and carbon-to-nitrogen (C:N) ratio were measured. Vetch treatment significantly increased soil nitrogen levels and altered the C:N ratio in plant tissues ($p < 0.001$), as well as enhancing (o "which in turn enhanced plant yield by...") yield by increasing the number of fruits per plant ($p < 0.05$). These results suggest that Vicia sativa contributes to improved soil fertility compared to spontaneous vegetation, significantly impacting plant yield. Continued monitoring will help determine the extent to which green manures can contribute to sustainable production in Mediterranean horticultural systems.

KEYWORDS

Common vetch, green manure, nitrogen fixation, soil fertility, cover crops, tomato productivity.

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GT 07 - 1022 - P

POTENTIAL OF CITRUS INDUSTRY SEWAGE SLUDGE TO SUPPLY NITROGEN AND PHOSPHORUS FOR CROP PRODUCTION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Citrus sewage sludge (CSS), a by-product of citrus wastewater treatment, is rich in nitrogen (N) and phosphorus (P), and can be therefore used as an organic amendment [1]. The aim of this research was to assess the ability of CSS and its derived biochar to supply N and P for crop growth.

The research was conducted in a greenhouse where wheat (3 plants) and sunflower (1 plant) were cultivated in pots. Biochar from CSS was produced by pyrolysis at 300°C (B300) and 400°C (B400). Two soils with similar texture but differing in carbonates content were used: S1 with 52% and S2 with 2% (w/w), respectively. Soils were mixed with 20% perlite in volume and amended with CSS, B300, B400, mineral fertiliser (ammonium sulphate or simple superphosphate) and organic fertiliser (chicken manure), to provide 30 mg N plant-1 in the N test and/or 50 mg P plant-1 in the P test.

After 104 days of plant growth for the N test and 93 days for the P test, plant total N, P and dry weight were determined. Then, the extent (%) to which tested organic amendments can substitute N or P mineral fertilizers (MFRV) was calculated as follows: MFRV (%) = (X uptakei – X uptakec)/(X uptakes – X uptakec) x 100, where X is total N or P content of plant, i, c, and s are N or P uptake by the crop in the treatment with alternative fertilizer, N or P uptake in the control treatment (CTR), and N or P uptake in the mineral fertilizer treatment.

Wheat dry weight ranged from 5.4 g (CTR and B300) to 9.2 g (CSS) in S1, and from 8.1 g (B300) to 12.9 g (ammonium sulphate) in S2. The MFRV was the highest in S1 in chicken manure (153%), followed by CSS treatment (140%), and B400 (121%). In contrast, in S2, the MFRV ranged from 2% (B300) to 32% (chicken manure), thus suggesting a soil effect on N supply sources.

In soil S1, dry weight of sunflower ranged from 3.8 g (B300) to 6.5 g (CSS), while in soil S2, varied from 1.8 g (CTR) to 8.7 g (B300). The MFRV values were generally higher in soil S2. In S1, B300 achieved the highest MFRV (69%), followed closely by B400 (63%), and CSS with 54%. In S2, CSS and B400 reached MFRV values of 84% and 75%, respectively, while B300 outperformed all treatments, exceeding 100%, indicating that it supplied more plant-available P than the mineral reference.

Overall, results of this study provide evidence that the CSS and its derived biochar are able to supply N and P for crop growth and that such an ability depends on soil conditions.

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GT 07 - 1024 - P

NUTRIENT DYNAMICS IN WINTER WHEAT AND LEGUME INTERCROPS UNDER DIFFERENT STRIP TILLAGE AND PLOUGHING IN ORGANIC AGRICULTURE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Faced with accelerating soil degradation and the challenges of climate change, sustainable agriculture requires solutions that support nutrient accumulation through ecosystem services [1–3]. Mixed cropping of cereals and legumes has the potential to optimize nutrient cycling, particularly nitrogen [2]. However, during the growing season, nutrient uptake in intercrops of winter wheat and forage legumes under strip tillage has received limited attention.

The aim of this study was to determine patterns of plant competition and nutrient uptake in intercrops of winter wheat (Triticum aestivum L.) and forage legumes (Medicago lupulina L., Trifolium repens L.) established using strip tillage in an organic agroecosystem.

It was found that winter wheat dominated the intercrops: the more favorable the growing conditions, the earlier and more strongly the forage legumes were suppressed. Incorporation of legume biomass into the soil by ploughing stimulated nutrient release from the legumes and enhanced nitrogen and phosphorus accumulation in winter wheat, especially during flowering and maturity stages. In contrast, strip tillage and sowing of winter wheat into forage legume crop reduced legume biomass and delayed nutrient availability. Therefore, nutrient accumulation in the aboveground biomass and grains of winter wheat grown in intercrops was lower compared to the treatment where legumes were incorporated by ploughing. During the growing season, as the amount of nutrients accumulated in the aboveground biomass of forage legumes increased, nitrogen and potassium accumulation in winter wheat decreased. White clover competed most strongly with winter wheat for potassium starting from BBCH growth stage 59–61. Nitrogen and potassium accumulation in intercrops ranged from 2.3 to 41.8 times higher than in sole winter wheat cropping.

Our results demonstrate that strip sowing of winter wheat into forage legumes promotes competition between crops and reduces the availability of nutrients released from legume biomass to winter wheat.

KEYWORDS

strip tillage, nutrients, Medicago lupulina, Trifolium repens, Triticum aestivum

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GT 07 - 1032 - P

AGROECOLOGY FOR SOIL FERTILITY AND FOOD SECURITY IN WEST AFRICA: THE CIRAWA PROJECT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Agricultural productivity in Africa remains constrained by multiple factors, including soil degradation, limited access to inputs, and climate vulnerability (1). Agroecology is recognized as a promising strategy to address these challenges, demonstrating potential to improve crop yields and food security (2). However, its adoption across different regions is still limited, partly due to the need for further scientific knowledge on novel and context-specific agroecological solutions.

The CIRAWA project (Agro-ecological strategies for resilient farming in West Africa, 2023–2027), brings together 14 institutions from Europe and West Africa with the aim of improving crop productivity, climate resilience and food security through agroecological approaches adapted to local conditions. Within CIRAWA, the University of Seville (US) leads two key activities: i) assessing soil fertility and defining crop fertilization protocols; and (ii) evaluating the potential of locally available agro-residues for composting and vermicomposting to produce quality organic fertilizers on farms.

The project focuses on smallholder farmers in eight selected regions of Cape Verde, Ghana, Senegal, and The Gambia, where 100 farms were selected and characterized according to soil properties, crop systems, and existing management practices. Based on the diagnosis, tailored agroecological strategies were co-designed and will be implemented during the 2025–2026 cropping seasons.

To assess the effects of the intervention, a set of Key Performance Indicators (KPIs) has been established. Those directly linked to the US objectives include soil organic matter (SOM) content, soil available phosphorus and potassium, residue dynamics, and crop yields. These indicators will be monitored over time. Preliminary findings are expected to show improved soil nutrient availability, modest increases in SOM, and enhanced productivity with socio-economic co-benefits.

ACKNOWLEDGEMENTS

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GT 07 - 1038 - P

THE EFFECTS OF NUTRIENT-LOADED BIOCHAR ON BIOLOGICAL NITROGEN FIXATION IN FABA BEANS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Mineral fertilisers used in agriculture affect the environment and, with rising fertiliser prices, threaten agricultural productivity and food security. Hence, sustainable practices are crucial for enhancing nitrogen (N) use efficiency and minimising environmental impact. Nutrient-loaded biochars (NLB) offer a promising solution by sequestering atmospheric carbon in the soil, providing slow, continuous nutrient release, and reducing nutrient loss. Research indicates that NLBs enhance N use efficiency and crop yields. Our research group has shown that biochar can retain N, and growing legumes on biochar plots can increase N availability for subsequent crops. Some biochars have also been shown to improve biological N fixation (BNF) in legumes by improving soil structure, balancing and availability of nutrients, and optimising of plant-microbe interactions. However, their specific effects on faba beans (Vicia faba L.) remain understudied.

This study examines the impact of NLBs on BNF in faba beans and N use efficiency in boreal agricultural soils using the 15N natural abundance method. The study was conducted in long-term biochar experimental fields at the Viikki Research Farm (University of Helsinki) on two contrasting soils: fertile Stagnosol and nutrient-poor Umbrisol. Spruce biochar was activated with either nitric acid or tap water. Acid-activated biochars were then nutrient-loaded with either organic N (cattle slurry and meat bone meal) or mineral N. A split-plot design was used, with three biochar treatments in Stagnosol and only cattle slurry-loaded biochar in Umbrisol, each at two rates: 0 biochar and the highest rates (15 t ha-1 in Stagnosol, 30 t ha-1 in Umbrisol). Fertiliser treatments include two mineral levels (30% and 100% of recommended rates) for Stagnosol and two types (no fertiliser and mineral fertiliser) for Umbrisol. In total, 72 plots were used, along with an additional 13 no-biochar control plots for oats (Avena sativa L.), to provide a non-N-fixing reference for the soil N isotopic baseline to estimate N fixation in faba beans. Faba beans were cultivated in the experimental plots. We measured aboveground biomass, CN content, N yield, and the 15N/14N ratio by a Leco CN analyser and isotope ratio mass spectrometer from the flowering stage of both plants.

In Stagnosol, BNF was not affected by any of the NLB treatments. However, a trend was observed where organic N-loaded biochars combined with 100% fertiliser showed higher BNF, possibly due to improved nutrient availability. In Umbrisol, both fertiliser levels and the biochar × fertiliser interaction significantly affected BNF. Additionally, the highest BNF was found in plots without biochar or fertiliser, while the lowest was in those with both biochar and mineral fertiliser, likely due to an excessive concentration of plant-available N, potentially suppressing BNF. Further studies are needed to understand the mechanisms and explore the effectiveness of NLB in boreal agriculture.



GT 07 - 1052 - P

EVALUATION OF NANOFERTILIZER ON YIELD AND FORAGE QUALITY OF SILAGE MAIZE GROWN ON A VOLCANIC ANDISOL IN SOUTHERN CHILE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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This work integrates two seasons (2024–2025) of field trials assessing the agronomic performance of Fusamel 12.60.08 (a phosphate fertilizer) and NanoEnergy (a nitrogen nanofertilizer), alone or combined with conventional fertilizers and NanoMobo, on silage maize grown on a volcanic Andisol near Temuco, Chile. The soil had pH 5.95, available phosphorus 25 mg/kg, and aluminium saturation 0.5 %. Thirteen treatments were arranged in a randomized complete block design with four replicates, comparing traditional 113011 mixes, Fusamel, urea, NanoEnergy (2–4 L/ha), and NanoMobo (1 L/ha) in various combinations. Measurements included plant establishment, biomass yield (DM), nutritional quality (crude and soluble protein, starch), fiber characteristics (ADF, NDF, digestibility), and plant maturity parameters. Average dry matter yields across treatments were 26.5 t/ha, reaching 28.5 t/ha in treatments combining Fusamel and NanoEnergy—an 8 % increase over conventional fertilization. Crude protein reached up to 7.8 %, with soluble protein up to 28.2 %. Fiber digestibility peaked at 74.2 %, and starch content reached 36 % in treatment T8 (combining reduced traditional mix, Fusamel, urea, NanoEnergy and NanoMobo). All treatments maintained optimal DM content for ensilaging (30–36 %) and did not delay physiological maturity or alter plant-to-cob ratios.

These results highlight that integrating nanofertilizers, especially NanoEnergy, with alternative P sources like Fusamel enhances nutrient-use efficiency, yield, and forage quality while reducing reliance on conventional fertilizers. Recent reviews (Singh et al., 2024) report that nanofertilizers can increase nutrientuse efficiency by up to 30 % and boost crop yields around 20 % compared to traditional fertilizers. Experimental evidence further shows that nitrogen nanofertilizers improve NUE by over 10–22 % through enhanced N uptake and reduced losses (Yang et al., 2023). Additionally, controlledrelease phosphate fertilizers—functionally similar to Fusamel—have been demonstrated to sustain P availability and improve uptake in acid volcanic soils. These findings suggest potential for sustainable nutrient management in volcanic Andisols under silage maize systems.

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GT 07 - 1056 - P

MODELLING PHOSPHORUS TURNOVER IN SOIL FROM COW DUNG BREAKDOWN

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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In southern Chile, most grassland systems are developed on acidic Andisols, with high P fixation capacity. Thus, in these soils, P is one of the major limiting factors for plant growth, and because of this fact, it is necessary to apply large amounts of organic and inorganic P fertilizers. The effects of applying fresh cow dung on phosphorus fractions in the soil profile, and other related soil properties (pH, aluminum, ammonium, and nitrate) in an acid Chilean Andisol were studied. Soil P-fractions were monitored for 6 months in soil columns that received dung pats on the surface. Columns were destructively sampled every month, and the soil was divided into 10 cm depth increments. Soil pH, and phosphate concentration increased in 0-10 cm fraction at 30 days. After this period the pH decreased from 5.4 to 4.9 at the same depth. Plant available P fraction (P-NaHCO3) fraction increased (69 to 72 mg kg-1) in day 60. Then this fraction showed a decrease of 10 mg kg-1, due to microbial activity and pH change. From 120 to 180 days, the P-NaHCO3 fraction recovered its original level. P-NaOH fraction decreased according to soil depth; this was correlated to the sonicated P-NaOH fraction increase. P-residual increased to 100 mg kg-1 at 40-60 cm depth of soil. P-HCl fraction decreased significantly ($p<0.01$) at all depths from 10 to 5 mg kg-1. Only an organic P-form was found (5-10 mg ml-1) in the leaching solution. 31P RMN indicated that this is an orthophosphate diester. Results showed phosphorus diffusion and fixation from 0-10 cm toward 30-60 cm, because of the lower organic matter content. A mathematical model for describing the P dynamic is proposed. Its parameters were calculated using the experimental data. No significant differences ($p>0.05$) were observed between experimental and calculated values of P-labil fraction, P-NaOH, and sonicated P-NaOH. However, the model was not able to simulate the behavior of P-HCl and P-residual fractions, and the difference between experimental and calculated values was significant ($p<0.05$). This work showed that a part of P from dung is stored in less available fractions, such as sonicated P-NaOH and P-residual. The amount of P in these fractions varies with time and depth. The reintegration of residual soil P and recycled sources of P to the global P cycle would be considered an effective solution to affront the growing demands for this non-renewable resource in grassland soils.

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GT 07 - 1062 - P

SOIL FERTILITY DIAGNOSIS IN GHANA AND SENEGAL TO INFORM AGROECOLOGICAL INTERVENTIONS WITHIN THE CIRAWA PROJECT

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Nutrients are finite resources, but essential for achieving sustainable crop productivity. However, many African smallholder farmers face limited access to mineral fertilizers, which alone cannot fully restore soil health. Agroecological approaches such as the use of on-farm or nearby produced organic amendments offer a crucial solution (1, 2). This practice fosters nutrient recycling, reduces dependency on external inputs, and enhances soil organic matter (SOM).

The CIRAWA project (Agro-ecological strategies for resilient farming in West Africa, 2023–2027) promotes locally adapted agroecological solutions to improve soil fertility, sustainability, and food security for smallholder farmers in West Africa. A total of 50 farms in Central Gonja (CG) and Nabdam District (ND) in Ghana, and Central West (CW) and North Zone (NZ) in Senegal were selected to participate in the project. As a first step, soils from these farms were sampled and characterized in 2024, with the aim of supporting data-informed agroecological planning for the 2025–2026 cropping seasons and providing a robust reference point for future impact assessment.

In Ghana, soils were generally neutral-pH and coarse-textured. SOM and total nitrogen (N) were low in CG (average 1% SOM, 0.05% total N), while ND showed higher values (2% SOM, 0.13% total N). Phosphorus (P) and potassium (K) deficiencies were widespread: Olsen P was below agronomic thresholds in 91.7% (CG) and 84.6% (ND) of farms, while K was deficient in 91.6% (CG) and 61.5% (ND).

Senegalese soils (CW and NZ) exhibited similar coarse textures and neutral to acidic pH, with some salinity issues. SOM levels were generally under 1.5%, and total N mostly under 0.1% across both regions. P and K deficiencies were also prominent: Olsen P was below thresholds in 87.5% (CW) and 80% (NZ) of farms, and available K deficient in 100% (CW) and 46.7% (NZ) of farms.

This baseline soil diagnosis highlights the urgent need for improved nutrient management based on locally available organic resources. CIRAWA interventions will include the production and application of organic amendments (e.g., composts and manure), followed by reassessment of key fertility parameters (SOM, available P and K) to evaluate impacts on soil health, crop performance, and socio-economic outcomes.

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GT 07 - 1075 - P

SHORT-TERM EFFECTS OF NUTRIENT-LOADED BIOCHAR ON EARTHWORMS IN BOREAL AGRICULTURAL SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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The increasing use of mineral fertilisers for global food production has led to severe environmental hazards. Therefore, enhancing nitrogen use efficiency is an important approach for sustainable agriculture to meet the rapidly increasing food demand while minimising the harmful environmental effects. Nutrient-loaded biochars (NLB), a relatively recent concept, have the potential to simultaneously sequester atmospheric carbon in the soil as a means of mitigating climate change, provide slow and continuous nutrient release, and reduce nutrient loss. However, NLB's interaction with soil biota, especially earthworms, is essential to ensure the efficient and safe application of NLB in the soil.

The study investigates the effect of three different NLBs on earthworm abundance, biomass, and mean weight in two contrasting southern Finnish agricultural soils: sandy clay loam (Stagnosol) and loamy sand (Umbrisol). The study was conducted in long-term biochar field experiments at the University of Helsinki's Viikki Research Farm. NLBs were prepared from spruce biochar, activated with nitric acid or tap water, and acid-activated biochars were then loaded with organic fertiliser (cattle slurry/meat bone meal) or mineral fertiliser. In a split-plot design, all NLBs treatments in Stagnosol and only cattle slurry-loaded biochar in Umbrisol were applied at two rates: 0 biochar and 15 t ha-1 in Stagnosol or 30 t ha-1 in Umbrisol. Fertiliser treatments include two mineral levels (30% and 100% of recommended rates) for Stagnosol and two types (no fertiliser and mineral fertiliser) for Umbrisol. NLB was applied to the topsoil layer in May 2023 before barley sowing in both soils. Post-harvest (2023), earthworms were sampled from randomly selected locations within each plot from holes with an area of (25x25cm2,28cm deep) by hand sorting and mustard extraction. Then counted, weighed, and identified (based on pigmentation).

Water-NLB did not affect abundance or biomass, but it reduced the mean weight of earthworms, while high fertiliser levels (100% fertiliser) decreased abundance. Neither mineral NLB nor cattle slurry NLB had any effect on abundance, biomass, or mean weight; however, a notable biochar x fertiliser interaction affected mean weight in cattle slurry-loaded biochar: 30% fertiliser increased the mean weight of earthworms per plot in plots without biochar. NLB (water and mineral-loaded) increased soil moisture. EC increased across biochar plots but was significant only with cattle slurry-loaded NLB. In Umbrisol, biochar did not affect abundance or mean weight, but mineral fertiliser significantly reduced both. Biochar and fertiliser and their interaction reduced earthworm biomass. Biochar increased soil moisture and EC. Overall, 15 t ha^{-1} NLB in sandy clay loam had minimal adverse short-term effects on earthworms, but 30 t ha^{-1} in loamy sand increased EC and reduced biomass, suggesting an application rate threshold. A follow-up study in 2025, after harvesting the spring wheat, will help to determine whether these effects persist or reduce over time.



GT 07 - 1080 - P

BIOTECHNOLOGICAL APPROACHES TO ENHANCE PHOSPHORUS USE EFFICIENCY IN SALT-AFFECTED SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Phosphorus (P) is an essential but non-renewable nutrient, whose inefficient use in agriculture poses both environmental and agronomic challenges. Despite the widespread application of P fertilizers, resulting in a surplus of 70% in soils, over 55% of global cropland still shows low to medium-low phosphorus use efficiency (PUE) [1]. This issue is particularly severe in semiarid Mediterranean areas, where high salinity and alkaline pH exacerbate P immobilization through precipitation, ultimately reducing crop yields and threatening food security [2].

To address this challenge, the use of salt-tolerant beneficial fungi, such as arbuscular mycorrhizal fungi (AMF) and endophytic fungi (EF), as biological tools to enhance phosphorus use efficiency (PUE) under saline conditions has been investigated [3]. Indeed, arbuscular mycorrhizal fungi (AMF) such as Funneliformis mosseae, Rhizophagus irregularis, Septoglomus deserticola and R. fasciculatus, have shown significant benefits in enhancing P, nitrogen (N) and potassium (K) uptake by 36, 22 and 19%, respectively in non-saline soils, thanks to phosphatase and other enzymes [4]. Moreover, also endophytic fungi (EF), such as Trichoderma harzianum, T. viride, Piriformospora indica and Penicillium spp., are non-pathogenic microorganisms living inside the root tissue of host plant. They have been demonstrated that are able to solubilize both organic and inorganic P by producing organic acids, P-related enzymes, siderophores and exopolysaccharides in non-saline soils [5].

The aim of this study was to isolate native AMF from salt-affected soils to be further characterised and evaluated for their soil P solubilization ability. In this work, five soil and plant samples were collected from both salt-affected and unaffected areas in southern Sicily. Soil physicochemical parameters were assessed unveiling various salinity levels and mycorrhizal colonization in wild plant roots was assessed microscopically. Preliminary results shows that AMF colonization ranged 0 to 25% and no correlation were observed with soil properties related to soluble salts. The next steps will focus on isolating native AMF and EF strains from these environments, screening them in vitro for their P-solubilizing capabilities, and testing their efficacy in pot experiments across a gradient of salinity levels.

This approach aims to identify native microbial consortia capable of enhancing P availability in saline soils, offering a sustainable strategy to improve nutrient use efficiency in challenging environments.

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GT 07 - 1084 - P

VINEYARD SOIL SUSTAINABILITY AND ECO-EFFICIENT USE OF WINE RESIDUES: INTERREG SUDOE PROJECT SOIL&WINERESIDUES

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The geographical area of the European Union (EU) corresponding to Portugal, Spain and the French regions of Nouvelle-Aquitaine, Occitanie and Auvergne, encompasses a wine-growing region steeped in ancient tradition, boasting the largest vineyard area in the EU (which is the world's largest wine producer). The wine sector in this area faces problems such as deteriorating soil health, the management of lignocellulosic residues (LCR) and the impact of synthetic pesticides and fertilizers. The Soil&WineResidues project, funded by the Southwest European Area Territorial Cooperation Programme (Sudoe), aims to move toward a production model based on the eco-efficiency and circular economy. Through the combination of various technological approaches, the use of LCR generated in vineyards is proposed "in situ" (without travel to a treatment plant) to improve the health of vineyard soils, develop commercial products, obtain renewable energy and minimize dependence and impact on synthetic agrochemicals such as pesticides and fertilizers.

This work will analyze how this challenge will be addressed. For the period 2025-2028, the state of the vineyard soil types, their health and the status of their ecosystem services will be examined. The current management of soil-vineyard systems and measures to be implemented in order to achieve the sustainability or recovery of these systems will also be analyzed. The role that LCR can play in achieving these goals through coordinated implementation of eco-efficiency, circular economy and biorefinery concepts will be of particular interest. The factors that promote/hinder the implementation of a circular economy and eco-efficiency model that entails the appropriate use of soil and LCR will be identified. In addition, two pilot activities, i.e., TERRAVITIS and ECOLAB, will be established within Soil&WineResidues, with stakeholders from each region, to assess the initial state and evolution of soil health, the potential use of LCR, and the study of common pesticides.

All this will allow for territorial-scale decisions in different vineyards with similar characteristics and transfer and capitalize on the results transnationally through more holistic management of vineyards in the Sudoe area. Furthermore, the development of rural areas will be improved through the efficient use of resources and productive capacity of their industries, thereby attracting human capital and increasing both the competitiveness and resilience of the wine sector in the face of climate change and future crises.



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This work was performed within the Unidad Asociada “Ecología Microbiana de Suelos” (id. UA 1723), USC – CSIC and the Unidad Asociada “Comunidades Microbianas del Suelo” (id. UA 1678), UVigo - CSIC.

GT 07 - 1087 - P

EFFECTS OF BIOCHAR AND HYDROCHAR FROM OLIVE MILL SOLID WASTES ON SOIL FERTILITY, SOIL MICROBIAL COMMUNITY AND GREENHOUSE GAS EMISSIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Each year, large amounts of waste are generated from olive oil extraction, posing risks of soil and water contamination and contributing to greenhouse gas emissions. Valorizing these residues as organic amendments can mitigate such negative impacts, enhance soil health, and promote the circular economy in olive groves. Emerging technologies such as pyrolysis, gasification, and hydrothermal carbonization convert these wastes into biochar or hydrochar, which can increase soil organic carbon, improve soil physicochemical properties, and generate renewable energy.

This study evaluates the effects of biochar derived from orujillo (dry olive cake), and both biochar and hydrochar from alperujo (two-phase wet olive pomace), as well as inoculated olive pomace, on soil nutrient availability, soil microbial communities (fungal and bacterial), and greenhouse gas emissions (MIRA CO_2/N_2O portable analyzer from Aeris Technologies, Inc.). A controlled incubation experiment was conducted using these materials alone or combined with an inorganic nitrogen source.

The application of orujillo biochar and inoculated alperujo biochar did not significantly affect CO_2 emissions or soil nitrogen availability compared to the control, suggesting limited stimulation of microbial activity. However, both treatments increased N_2O emissions. In contrast, biochar and hydrochar from alperujo significantly increased CO_2 emissions, indicating enhanced microbial activity. Fungal and bacterial communities responded differently to biochar and hydrochar from alperujo compared to orujillo biochar and inoculated biochar. The higher microbial activity associated with alperujo biochar and hydrochar reduced nitrogen availability during the first 30 days of incubation when not supplemented with inorganic nitrogen. Notably, these treatments did not increase N_2O emissions relative to the control, suggesting that biochar and hydrochar from alperujo may temporarily limit nitrogen availability, potentially mitigating N_2O emissions in agricultural soils.

ACKNOWLEDGEMENTS

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GT 07 - 1088 - P

BIOCHAR FROM OLIVE RESIDUES: ENHANCING ITS FERTILIZING POTENTIAL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The use of organic amendments is a key strategy for promoting sustainable agricultural practices through the efficient utilization of agricultural waste, enhancement of soil fertility, and mitigation of greenhouse gas (GHG) emissions. In this study, we evaluated the effects of biochars derived from olive industry residues—olive pomace, olive stone, and pomace+wood (carbon-rich materials). These biochars were applied individually or in combination with nitrogen-rich organic amendments, such as sheep manure and vermicompost, to assess their impact on soil nutrient availability, soil microbial communities (fungal and bacterial), and GHG emissions. Gas emissions were measured using a MIRA CO_2/N_2O portable analyzer (Aeris Technologies, Inc.) under controlled laboratory conditions over 100 days.

The individual application of olive pomace biochar, sheep manure, and vermicompost increased soil phosphorus availability. Similarly, combinations of olive pomace biochar or pomace+wood biochar with sheep manure also enhanced phosphorus availability compared to the control. However, this effect was not observed when biochars were combined with vermicompost.

Across all treatments, N_2O emissions remained similar to those from the control soil. In contrast, CO_2 emissions significantly increased following the application of olive pomace biochar, whether alone or combined with other organic amendments. These three treatments (olive pomace biochar applied alone or combined with sheep manure or vermicompost) led to shifts in both bacterial and fungal communities compared to the other treatments. The observed increase in microbial activity contributed to nitrogen immobilization in the soil due to the high carbon inputs. Nevertheless, when olive pomace biochar was combined with sheep manure, no reduction in soil nitrogen availability was detected. These findings suggest that co-application of carbon-rich olive pomace biochar and nitrogen-rich sheep manure can enhance soil carbon sequestration without compromising nitrogen availability for olive cultivation.

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GT 07 - 1094 - P

INVESTIGATING THE EFFECTS OF BIOCHAR-PEAT AMENDMENTS ON ORGANIC MATTER DYNAMICS IN LOW CONTAMINATED URBAN SOILS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Urban soils are essential for ecosystem services but are often degraded and contaminated by heavy metals and polycyclic aromatic hydrocarbons (PAHs). Biochar, a carbon-rich material produced via biomass pyrolysis, has emerged as a promising amendment for remediating contaminated soils through adsorption and immobilisation. Its environmental persistence also makes it a recognised negative emission technology (IPCC, 2023), with potential to enhance soil organic carbon (SOC) stocks. However, long-term field data on its effectiveness in urban soils remain limited.

This study, in collaboration with the Swedish Geotechnical Institute (SGI), investigates the long-term (2019–2023) effects of biochar and peat amendments on SOC dynamics in a low-contaminated urban soil in Sweden. A full-factorial field trial was established using perennial ryegrass and treatments of biochar (0%, 3%, 6% w/w) and peat (0%, 3% w/w) (1). Soil samples were analysed using thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), quadrupole mass spectrometry (QMS) (2), elemental analysis, and proximate analysis.

Results showed that biochar significantly increased total organic carbon (TOC) and the proportion of thermally stable (refractory) SOC compared to control and peat-only treatments. The 3% biochar with 3% peat (BC3P3) treatment was most effective, enhancing SOC stability while minimising potential losses. Over four years, a shift from refractory to more recalcitrant SOC was observed, suggesting redistribution or transformation of biochar in the soil profile. Broader CO_2 emission peaks in 2023 supported this trend.

Peat-only treatments increased labile SOC, while combined biochar-peat amendments showed synergistic effects on SOC retention. The highest TOC gains were observed in the 6% biochar with 3% peat treatment (BC6P3). A decline in refractory carbon in 2023 may reflect biochar movement below sampling depth or surface loss (3). Increased inorganic carbon in 2023 soils may be linked to peat liming effects.

This study highlights biochar's potential to enhance SOC stability and support contaminant remediation in urban soils. Importantly, the findings also suggest that biochar could partially or fully substitute conventional amendments such as peat—offering a more sustainable, climate-resilient alternative for urban soil restoration.

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GT 07 - 1097 - P

EVALUATION OF THE EFFICACY OF PLANT BIOSTIMULANTS FROM URBAN COMPOST TEA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Plant biostimulants, recently regulated by the EU (PFC 6, 2019/1009), can be an alternative to urban or agro-industrial compost that, due to their lower NPK content, cannot be classified as organic fertilizers and are used as organic soil improvers. In this study, a plant biostimulant from compost tea derived from urban waste is tested with the aim of evaluating its ability to stimulate plant nutrition processes, regardless of their nutrient content. Plant biostimulant is chemically characterized: Total Organic Carbon (TOC), macro- and microelement (N, P, K, Ca, Mg, K, Na, Fe, Mn), and heavy metal limit content (Cd, Cr VI, Pb, Hg, Ni, As, Cu and Zn), in addition to phytotoxicity tests and pathogens. An efficacy trial was conducted on lettuce (oak leaf variety) during the spring-summer months, with 60 plants per trial (20 plants per treatment): urban compost tea (BIO 1) and a control (C); a base nutrient solution was used in all trials. Chemical and biology characterization of compost tea demonstrated that it can be classified as non-microbial plant biostimulant within EU regulations, given their low heavy metal content and microbial safety. However, the plant biostimulant exhibited high phytotoxicity, requiring a 2.5% dilution in BIO 1. Bioproduct dose being applied was determined based on the crop's nutritional and water requirements throughout the growing cycle; the biostimulant was initially applied once a week and subsequently twice a week, in sufficient quantities to supply weekly nutritional needs. Plant height, leaf number, and leaf area index were measured weekly up to 60 days after transplanting. At the end, the plants were harvested to calculate the relative water content (RWC), total biomass (assimilative biomass and root biomass), root length and shape, and to determine the soil-plant nutrient uptake balance. Preliminary results showed significant differences in leaf growth in BIO 1 at 30 days after transplanting; the number of leaves did not show significant differences. Since all treatments had the same based nutrient solution, the difference found can be attributed to the biostimulant effect, making it possible to establish the minimum response dose of the biostimulant BIO 1 (2,5%) at 2-7 l/m2.

In conclusion, the use of urban compost tea as a plant biostimulant can be a sustainable solution for crops growth. Since application rates cannot be generalized, it is recommended to carry out efficacy tests by type of biostimulant and crop.

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GT 07 - 1107 - P

AGROECOLOGICAL STRATEGIES FOR ENHANCING SOIL FERTILITY AND CROP PERFORMANCE IN MEDITERRANEAN BROCCOLI CULTIVATION

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Broccoli (Brassica oleracea L. var. Italica), belonging to the Brassicaceae family, is a nutritionally dense horticultural crop of considerable agronomic and economic relevance, originating from the Mediterranean basin. It is characterized by a low caloric value, while being a rich source of vitamins C, K and A, along with minerals such as potassium, calcium and iron, and health-promoting phytochemicals such as glucosinolates. Conventional agricultural practices often rely on synthetic fertilizers to enhance productivity; however, their excessive use can lead to environmental degradation, and potential risks to human health. In contrast, organic fertilizers contribute to improved soil physicochemical properties and stimulate beneficial microbial activity.

This study aimed to evaluate the interactive effects of microbial consortia and diverse fertilization regimes on the morpho-biometric, agronomic, and qualitative parameters of broccoli. Two open-field experiments were conducted in distinct zones of Sicily—Granieri (CT) and Paternò (CT). A factorial experimental design was employed to assess the influence of fertilization treatments (including organic amendments, biochar, and their combinations) and microbial inoculants (including PGPR and mychorrizae) on plant performance. Results demonstrated that shoot height, curd fresh weight, and curd diameter were significantly affected by both site-specific environmental conditions ($p < 0.001$) and fertilization strategy ($p < 0.001$). The highest values for these parameters were recorded in plots treated with organic amendments in combination with biochar. Although microbial inoculation exhibited marginal improvements in certain parameters, these effects were not statistically significant ($p > 0.05$).

These findings underscore the potential of integrating organic soil amendments and biochar as a sustainable fertilization strategy to enhance broccoli productivity. While microbial inoculants alone did not yield significant agronomic benefits under the tested conditions, their role in long-term soil health and resilience warrants further investigation. The adoption of such agroecological practices may contribute to improved soil fertility, and sustainable crop production systems.



GT 07 - 1109 - P

A NOVEL PHAGE-BASED SOIL CONDITIONER INCREASES NITROGEN USE EFFICIENCY IN CROPLAND

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 04. SOIL BIOLOGY

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Current agricultural systems are challenged by the rapidly increasing cost of nitrogen (N) fertilisers and the impact of climate change on soil and crop health. Soil conditioners based on natural products have gained increasing attention for supporting crops through various mechanisms, including enhanced plant tolerance to biotic and abiotic stresses, such as resistance to pathogens or improved nutrient acquisition.

The majority of soil conditioners currently available in the market are either based on natural chemical compounds (such as humic acids) or bioinoculants based on single strains of microorganisms. Single strains have a short-term benefit, since the existing soil microbiome quickly outcompetes them.

We present a novel, phage and virus-based soil conditioner, developed from a range of natural sources and processed to deliver a mixture of humic acids and a physically selected cocktail of bacteriophages (phages) and soil viruses. The introduction of this product for use in agricultural systems provides the combined benefits of humic acids and a cocktail of soil phages and viruses. Unlike single microbial strains, this cocktail can thrive within the soil microbiome networks and become established, with a long-term capacity to modulate a wide range of soil microbiome functions. Thus, this new concept of soil conditioner simultaneously improves key processes, such as root development, through the presence of humic acids, and enhances nutrient availability through bacterial control mediated by soil phages and viruses. Overall, the introduction of this conditioner into agricultural systems can substantially reduce the application of fertilisers, pesticides, and fungicides, resulting in key economic and environmental benefits.

We tested the feasibility of this soil conditioner in a two-year field trial (2023-2024) for four wheat genotypes, including modern cultivars and landraces. The conditioner was applied at two doses in the first season (4 L/ha and 8 L/ha), four days after sowing. For the second season, the conditioner was applied at 4 L/ha to the plots that received 4 L/ha in the first season, again after sowing. Plots that received 8 L/ha in the first season did not receive any further application in the second season to test the residual effect of the conditioner. In the first season, we applied a 15N-enriched fertiliser to assess the increase in N use efficiency (NUE) quantitatively.

We found that the conditioner significantly decreased soil microbial nitrification rates in the first season, particularly in the rhizosphere of modern cultivars, resulting in increased N uptake by the plant and higher levels of several essential nutrients in the seed. In the second season, we observed a consistent decrease in nitrification rates across all cultivars tested, confirming the long-term effect of the phage/virus cocktail on the recruitment and establishment of rhizosphere soil microbiome and the crop system.

Overall, we present evidence that the application of our novel soil conditioner in crop systems results in a beneficial recruitment of the soil microbiome, leading to a modulated nitrification rate that enables the crop to maximise N uptake and promotes natural nutrient cycling in the crop rhizosphere.

GT 07 - 1118 - P

TRANSPORT OF HYDROXYAPATITE NANOPARTICLES IN AGRICULTURAL SOIL COLUMNS: INFLUENCE OF SOIL TYPE AND DOSE

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Hydroxyapatite, Ca10(PO4)6(OH)2, is a compound with fertilizer potential due to its ability to release calcium (Ca) and phosphorus (P), while also acting as a low-impact environmental amendment. This study aimed to evaluate the mobility of hydroxyapatite nanoparticles (NPHA) through leaching tests in soil columns, assessing their agronomic efficiency and potential environmental risks. NPHA were synthesized by reacting H3PO4 and Ca(OH)2 under constant agitation, followed by drying at 60 °C, and grinding to nanoscale size.

Four doses (0, 30, 120 and 300 kg ha-1) of NPHA were tested using two agricultural soils: S1 (loam, pH 5.6, 12.5% OM) and S2 (sandy loam, pH 6.6, 2.9% OM). Column assays were conducted over 24 h using a constant water flow (5 mL h^{-1}), collecting 20 fractions per column. Leachates were analyzed for pH, dissolved organic matter (DOM), and Ca and P concentrations.

For pH analysis, soil S1 showed high variability, with initial fluctuations attributed to immediate interaction with NPHA, before stabilizing around pH 6. In contrast, S2 showed a more uniform trend, with initially lower pH that gradually increased until stabilization. The concentration of accumulated DOM released over 24 h of leaching were higher in S1 (0.24 - 0.30 mg kg-1) than in S2 (0.08 - 0.15 mg kg-1), whose behavior agrees with the soils initial SOM content.

Regarding accumulated Ca concentrations over 24 h, no clear dose-dependent pattern was observed in either soil. In S1, Ca concentrations in the leachates increased from 8 mg L-1 in the control soil up to ≈ 32 mg L-1 with the 120 kg ha^{-1} and 300 kg ha^{-1} doses. In S2, the concentrations were similar for control and different doses (≈ 35 mg L-1) suggesting possible retention of calcium in this soil. Moreover, the calcium concentrations in the leachates remained within non-toxic ranges for plants, indicating no apparent phytotoxic risk.

In contrast, phosphorus showed a clear dose-dependent trend in both soils. In S1, P concentrations nearly doubled from the control (7.9 mg L-1) to the highest dose (16.7 mg L-1). In S2, the increase was even more pronounced, from 4.6 mg L-1 at 0 kg ha^{-1} to 11.8 mg L-1 at 300 kg ha^{-1}. This confirms the high mobility of phosphorus from NPHA, raising concerns about potential leaching risks and environmental contamination.

These results underscore the importance of adjusting the application doses of nanoparticles as agrochemicals according to soil characteristics and crop needs. NPHA shows a promising profile as a fertilizer for smart agriculture but requires responsible use to avoid negative environmental impacts and ensure sustainable and precise agriculture.

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GT 07 - 1122 - P

EFFECT OF ORGANOMINERAL FERTILIZERS ON THE EXCHANGEABLE AND SOLUBLE FRACTIONS OF PHOSPHORUS IN ANDISOLS OF COLOMBIA

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 02. SOIL PHYSICAL CHEMISTRY

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Colombian Andisols are characterized by phosphorus (P) retention ≥ 90 %, resulting in low P availability and solubility over time, which impedes meeting crop requirements. Consequently, high rates of phosphate inputs are necessary to satisfy critical demands, yet the low efficiency of these fertilizers underscores the need for technologies that enhance both exchangeable P (P int) and soluble P (P sol) availability for crop nutrition. This study evaluated P fraction dynamics following applications of organomineral fertilizers (OMi) versus conventional chemical fertilizers (CF). At the Montelindo Farm (University of Caldas; 1050 m.a.s.l.; mean annual precipitation 2150 mm), Typic Melanudands were planted with two successive cycles of Zea mays. Treatments consisted of 0, 30, 45, and 60 g*m^{-1} linear of OMi, and 15 and 30 g*m^{-1} linear of DAP and MAP. Soil samples were collected at 0–10 and 11–20 cm depths at 0, 15, 30, 60, 90, and 120 days after fertilization. Analysis included exchangeable P (Bray II), soluble P (P-sol; saturated paste extract), pH (1:1), and Soil Organic Carbon (SOC; Walkley–Black). Grain yield (dry matter) was also measured.

In unfertilized control plots, P int at 0–10 cm averaged 56.85 mg kg^{-1}. OMi treatments yielded mean P int values of 54.70, 52.21, and 57.08 mg kg^{-1} at 30, 45, and 60 g m^{-1} doses, respectively. DAP applications produced P int concentrations of 79.25 and 64.06 mg kg^{-1}, while MAP resulted in 63.15 and 74.31 mg kg^{-1}; differences among fertilizer types and rates were not statistically significant. At 11–20 cm, control P int was 50.06 mg kg^{-1}; OMi treatments recorded 51.63, 48.80, and 50.63 mg kg^{-1}, DAP 66.22 and 64.75 mg kg^{-1}, and MAP 57.31 and 55.88 mg kg^{-1}, again without significant differences.

P sol concentrations between 0 and 30 days post-application ranged from 0.4 to 1.4 mg*L^{-1} for DAP and MAP, whereas OMi released between 0.2 and 0.6 mg*L^{-1}, indicating a rapid, high initial solubilization from chemical fertilizers. After 60 days, P sol from CF dropped to 0–0.2 mg*L^{-1}, while OMi sustained 0.4–0.6 mg*L^{-1}, demonstrating a more controlled, prolonged release. Soil acidity declined more sharply with CF (pH from 5.81 to 5.32) than with OMi (pH 5.81 to 5.63). SOC decreased from 4.46 % to 4.14 % under CF and from 4.49 % to 4.41 % under OMi, with no significant differences between treatments. Mean grain yields were 10.95 t*ha^{-1} (DAP), 12.84 t*ha^{-1} (MAP), and 15.15 t*ha^{-1} (OMi).

These results indicate that while OMi and CF supply comparable amounts of exchangeable P to the soil, chemical fertilizers exhibit rapid P migration and diminished availability beyond 30 days. In contrast, OMi maintains more stable P int concentrations in the topsoil across two maize cycles. Integrating organic and mineral P sources thus represents a viable strategy for sustained P release and improved crop nutrition.

KEYWORDS

Soluble phosphorus; exchangeable phosphorus; organomineral fertilization; Andisols; maize.

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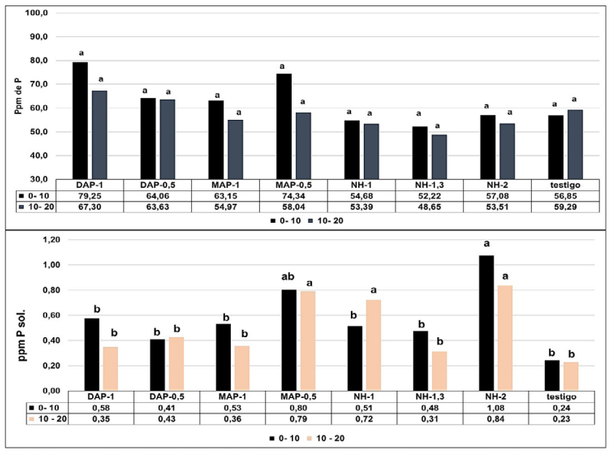


Fig. 1. Average values of P-int (A) and P-sol. (B), expressed in ppm of PO4-3. (Different letters indicate differences at the same depth, 0.05).

GT 07 - 1131 - P

ORGANIC FERTILIZER DERIVED FROM PYURA CHILENSIS TUNICAE: TWO-HARVESTS EVALUATION OF GROWTH AND NUTRIENT UPTAKE IN LETTUCE UNDER GREENHOUSE PRODUCTION IN A VOLCANIC SOIL

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Pyura chilensis is a tunicate marine filter-feeder whose extraction generates thousands of tons of residues annually on the coast of the Región de Los Lagos, Chile. The objective of this work was to evaluate the use of semi-composted tunicae residues as an organic fertilizer for greenhouse vegetable production in a volcanic soil (Typic hapludand) of low-to-medium nutrient availability. During the winter and spring season, lettuce (Lactuca sativa) plants were sequentially cropped twice under greenhouse conditions in a complete randomized block design with 3 replications (blocks). A plot of 1 x 0.5 m with 5 plants each was the experimental unit. The treatments consisted of 2.05 kg/plot of the organic amendment (OAM) or the chemical standard fertilization (CHF) both equivalent to 80 kg N/ha, 65 kg P2O5/ha, and 56 kg K2O/ha. Chemical fertilization included 20 kg S/ha, while, given the composition of the OAM, there was an input of 42-173 kg S/ha depending on the application rate. Fertilization was carried out by homogeneously incorporating the organic and inorganic materials in the upper 5 cm of the soil before the transplant of the first crop cycle. Treatments with 0.5x and 2x the OAM rate and a control without fertilization were included as well. After harvest, nutrient uptake and aerial and root dry matter (DM) of plants were determined, and soil fertility analyses were performed. Dry matter of plant increased with the OAM rate, and there was a strong positive correlation ($p<0,001$) between root and aerial growth of plants. At the first harvest highest DM production and uptake of N and P were observed with CHF and the highest OAM rate ($p<0.05$). At the second harvest, DM production was similar for organic and chemical fertilized treatments, but the uptake of N, P, and K was increased in some of the treatments receiving the OAM indicating that its nutrient supply was keep over time. Also, Na levels were markedly increased with the OAM rate. The use of this OAM of marine origin could be a good alternative for recycling nutrients and its availability in Andisols for small scale greenhouse producers.

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GT 07 - 1139 - P

GROWTH AND YIELD RESPONSES OF RICE (ORYZA SATIVA L.) TO MICROBIAL-ENRICHED NPK FERTILIZATION IN FIELD CONDITIONS

GT 07. SOIL AMENDMENTS & FERTILIZERS / GT 09. SOIL HEALTH

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Introduction:

Microbial-enriched fertilizers are gaining attention as sustainable alternatives to conventional fertilizers due to their potential to enhance crop productivity, nutrient uptake and disease resistance[1]. This study aimed to evaluate the effects of two types of microorganism-rich NPK fertilizers (R7 and H1) on rice growth, yield and soil properties under field conditions.

Material and Method:

Field experiments were conducted using five treatments: Control (no fertilization), NPK, NPK+R7 (Basal only), NPK+R7 (Basal + Top dressing) and NPK+H1 (Basal + Top dressing). Standard fertilization rates were applied, and microbial fertilizers were incorporated according to the treatment plan. Plant height, yield components (panicles per m2, grains per panicle, 1,000-grain weight and ripening rate), and nutrient content (N, P, K, Ca, Mg) of plant tissues were measured. Additionally, post-harvest soil physicochemical properties were analysed.

Results:

Rice yield increased in the order of NPK+H1(B+T) > NPK+R7(B+T) > NPK+R7(B) > NPK > Control. The NPK+H1(B+T) treatment had the highest number of grains per panicle, while NPK+R7(B+T) showed the highest panicle density per area. Plant height was significantly greater in NPK+R7(B+T) compared to NPK, suggesting enhanced vegetative growth. Nutrient analysis revealed higher K and Mg content in the stem of the Control group, whereas grain nutrient levels did not differ significantly among treatments. Post-harvest soil analysis showed a general decrease in EC and CEC across treatments, with minor differences among groups. In pepper, powdery mildew occurred in all treatments, but NPK+H1(B+T) showed the lowest disease severity, though not statistically significant.

Notably, gray mold incidence was significantly reduced in NPK and NPK+R7(B+T) treatments compared to Control and NPK+H1(B+T) ($p < 0.01$). This suggests a potential role of microbial fertilizers in enhancing disease resilience in greenhouse-grown crops.

Conclusion:

Microbial-enriched NPK fertilizers, particularly R7 and H1, improved rice yield and growth performance under field conditions without adversely affecting soil quality. These results suggest their potential for sustainable rice production and warrant further long-term studies to validate their effectiveness across diverse environments.

KEYWORDS:

Rice, Microbial Fertilizer, Plant Growth, Nutrient Uptake, Soil Health

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GT 08. SOIL-PLANT-WATER INTERACTIONS

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 08 - 20 - O

HARVESTING OF AGRICULTURAL NUTRIENT RUNOFF WITH ALGAE, TO PRODUCE NEW SOIL AMENDMENTS FOR URBAN AND PERI-URBAN OLIVE TREE AGROFORESTRY SYSTEMS IN SOUTHERN EUROPE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Biomimicking has long been an interest of many scientific and engineering fields. When two ecosystems overlap, we have the famous edge effect. In this article, we want to explore getting the same abundance of life using a biomimicry approach to agroforestry by bringing aquatic life full of nutrients to the soil. These nutrients would otherwise harm the marine ecosystem and in this way, as they get removed before reaching the sea, they help grow life on land, while preserving marine life. Nature-based solutions to water management are usually grouped into five established categories, adding to this well-established lists could be harvesting agricultural nutrient runoff with microalgae, and using them as soil amendment in peri-urban and urban settings, especially focusing on olive trees in and around Mediterranean and Greek cities. The ancient olive tree is a cornerstone for further research, not only because of its general tolerance to drought, very easy management, somewhat salt tolerance, but above all its overwhelming presence in the whole Mediterranean basin. Here we will try to identify at least three most accessible sites for implementing a nutrient runoff harvesting system using algae in Greece. These sites will be characterised by infrastructure development, levels of nutrients present in the waters, vicinity to an urban area as well as vicinity to a highly cultivated area, local willingness to experiment and collaborate in for developing an urban (or peri-urban) agroforestry system with the traditional olive tree as the central income-generating species. The main research methodology consists of an extensive multidisciplinary literature review, aimed at gaining valuable insights on three issues. Firstly, the source location of the nutrient runoff that produces the algal blooms shall be identified. Secondly, treatment methodologies and practices identified to generate biostimulants and soil amendments from algae are highlighted. Thirdly, identifying the best combination of plants and crops to support nutrient absorption and complement the olive trees' growth.

Keywords: Urban agroforestry, agroforestry, peri urban agroforestry, soil amendments, regenerative city spaces, water recycling, waste recycling, circular cities, algae harvesting system, nutrient runoff harvesting system using algae.

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GT 08 - 24 - O

STUDYING THE INFLUENCE OF SOIL CHEMISTRY MOSAIC ON PLANT DIVERSITY IN THE UISU GLACIER FORELAND, EASTERN PAMIR: HAS TIME STOOD STILL?

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The study was conducted in the Koksoy Valley, on the foreland of the Uisu Glacier in the Eastern Pamir Mountains (Tajikistan) in the summers of 2018 and 2019. The aim was to understand the variation in soil chemistry in different landforms in the valley, including poorly developed terraces often eroded by glacial rivers, alluvial fans and relatively intact terminal moraines at the end of the 14 km long valley. The harsh, arid climate, soil water deficit and strong convective winds limit vegetation growth in the study area. As a result, chamaephytes and hemicryptophytes dominate – perennial plants that reproduce vegetatively and are adapted to protect themselves from sand and dust. The most common habitats are deserts and steppes, characterized by dwarf shrubs and cushion plants. Further from the glacier front, on the most distant terrace of the terminal moraine, the aeolian dune region is dominated by perennial grasses and sedges, while the deflation fields have a sparse shrub cover, mainly Dracocephalum heterophyllum.

Soil chemistry (pH, EC, TC, TOC, TN, N-NH4, N-NO3, P-PO4) and biodiversity indices (Shannon index, species richness, evenness, vegetation cover) were analyzed. ANOVA analysis showed significant differences between the studied landforms (terraces) in terms of C/N ratio, soil pH and biodiversity indices (H, S and vegetation cover) ($p < 0.05$). Tukey's post hoc tests confirmed that the terraces differed regarding C/N ratio, soil pH, and biodiversity indices.

Multiple regression analysis with species richness (S) as the dependent variable explains 35.5% of the variance, with an adjusted R-squared of 33.2%, indicating a moderate fit. Total nitrogen (TN) is a statistically significant predictor of vegetation cover ($p = 0.000$) and shows a strong positive relationship, while the C/N ratio does not significantly affect vegetation cover in this model ($p = 0.542$). The relationship between species richness (S) and distance from the glacier is not strictly linear. While proximity to the glacier is an important factor in determining biodiversity, specific features of each terrace—such as soil chemistry, moisture, microhabitats, and stage of ecological succession—also play a key role in shaping the diversity of species present.

ACKNOWLEDGEMENTS

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The Polish National Science Centre supported this work

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GT 08 - 113 - O

ROOT TRAITS OF DIFFERENT WHEAT CULTIVARS INFLUENCE SOIL STRUCTURE AND HYDRAULIC PROPERTIES

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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Plant roots play a crucial role in maintaining soil health by influencing physical structure and hydraulic properties [1]. This study investigates relationships between root morphology of wheat genotypes and their impacts on soil structure and hydraulic characteristics. Using shovelomics [2], we characterized root systems of wheat cultivars (Paragon, Bologna) and landraces (Senatore-Cappelli, Watkins238) selected for contrasting root morphologies [3]. X-ray computed tomography (CT) was applied to examine soil pore networks at cylinder and aggregate scales [4], while soil hydraulic properties were measured using Wind evaporation and dew point techniques [5].

Results demonstrated significant genotype-driven differences in soil morphology and hydraulic functions. Structural analyses (Minkowski functionals, percolation theory) showed significant variability in bioporosity and pore connectivity among genotypes compared to bare soil. Senatore-Cappelli exhibited notably larger biopores (>1 mm diameter). Hydraulic characterization using a van Genuchten bimodal model revealed statistically significant differences in soil water retention curves and hydraulic conductivity among genotypes. Root traits, including total root length, branching frequency, lateral root length, and root diameter, significantly correlated with soil pore size distribution and hydraulic parameters (Alpha1, Alpha2).

This analysis underscores the importance of root architecture in modulating soil structure and water dynamics, highlighting the potential of specific wheat genotypes to enhance soil health, water retention, and agricultural sustainability. Findings support selecting optimal root traits to improve crop resilience and water-use efficiency.

ACKNOWLEDGEMENTS

This research was partially funded by the WISH-ROOTS project (EU Horizon 2020, EJP Soil), the BBSRC (project BB/X003000/1), and the PhD program of the Department of Agricultural and Food Sciences, University of Bologna. B.G. Dimattia also acknowledges support from the Collegio Superiore and the Institute of Advanced Studies, University of Bologna.

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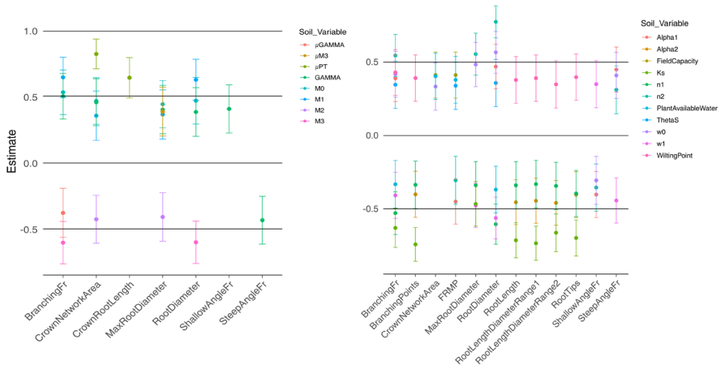


Figure. Estimated fixed effects (± SE) from linear mixed models evaluating the relationship between root traits (X-axis) and soil parameters (Y-axis). Left panel: Associations between root traits and soil physical parameters (e.g., total porosity (M0), euler hindex (M3)). Right panel: Associations between root traits and soil hydraulic properties (e.g., PAW, Ks). Only statistically significant results ($p < 0.05$) are shown in the figure.

GT 08 - 138 - O

ARTIFICIAL MACROPORES - A NEW APPROACH TO ENABLE PLANT ROOT ACCESS INTO SUBSOILS, IN THE PRESENCE OF SOIL COMPACTION

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil compaction adversely impacts key soil functions, notably by restricting root depth distribution. However, the presence of vertical macropores facilitates root access to water and nutrient reservoirs in subsoils. Mechanical amelioration strategies are often prone to recompaction and may destroy soil structure. However biological drilling with taprooted perennial plants or earthworms also showed limited potential for amelioration at a certain level of subsoil compaction. This highlights the need for innovative remediation approaches potentially based on vertical pores. We built artificial macropores as preferential pathways into the subsoil, particularly within compacted layers to restore soil functions and enhance plant productivity.

The objective of this study was to assess the colonization of artificial pores by roots and anecic earthworms, as well as their effects on root depth distribution and yield of winter wheat. We hypothesized a positive effect of artificial macropores on root depth distribution and crop yield.

Two randomized, fourfold replicated field trials were established in Central and Northeastern Germany. In total, 11,500 artificial macropores (8 mm in diameter) were manually created down to a depth of 80 cm. The experimental design included treatments with 50, 100, and 200 artificial macropores per square meter. Root depth distribution within 0–100 cm was analyzed using a convolutional neural network-based image analysis approach.

First-year results showed that 83% of the artificial macropores were colonized by at least one winter wheat root, while 1% were colonized by anecic earthworms within four months after pore creation. Wheat yields increased by 9% at the sandy loam site with 100 artificial macropores per square meter, and by 1%, 3%, and 6% at the clay loam site with 50, 100, and 200 macropores per square meter, respectively. The control plots contained 64 biological macropores per square meter at the sandy loam site and 70 at the clay loam site. In these natural macropores, 70% were colonized by at least one root and 7% by anecic earthworms at the clay loam site. These findings suggest that artificial macropores represent a promising strategy to enhance root depth distribution and improve yields in soils affected by subsoil compaction. Updated results covering the second sampling year from the two sites will also be presented and discussed.

ACKNOWLEDGEMENTS

Soil compaction, root depth distribution, artificial macropores

GT 08 - 213 - O

'ANTI-CAPPING' POLYMERS SIGNIFICANTLY ENHANCE EMERGENCE, STAND ESTABLISHMENT AND YIELD IN BABY LEAF SPINACH.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 05. SOIL HYDROLOGY & EROSION

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Rainfall and irrigation drop impacts at the immediate soil surface destroy soil aggregates through the concomitant processes of slaking, physico-chemical dispersion and particle re-organization. This can result in the formation of a structural soil that upon drying forms an impermeable surface crust. This can cause reductions in seedling emergence, stand establishment, crop uniformity and final yield. Light textured soils which are well suited to baby leaf spinach are often highly susceptible to crusting.

The efficacy of anionic synthetic and to a lesser extent natural polymers to prevent aggregate breakdown, crusting and erosion has been documented for >40yrs. However, to date practical adoption has been limited due to issues of polymer viscosity. New anionic synthetic polymer formulations now allow successful polymer spray application to the immediate soil surface.

During June-September 2024, two replicated baby leaf spinach trials were established with an 'Anti-Capping' anionic polymer applied using conventional spray nozzles (Lechler Flat Fan 03) 1 Day after Drilling (DAD) at application rates of 14, 20 and 26 litres (l) of active ingredient (a.i) ha-1 as compared with an untreated Control. All treatments were replicated in quintuplicate. Treatment performance was evaluated in terms of emergence per linear meter, stand establishment and final yield.

In addition, two spinach seeding rate trials were also conducted that ran in parallel to the replicated trials. These investigated a seeding rate of 9.4 M seeds per ha-1 as compared with and rate of 8.1 M seeds per ha-1 to which 'Anti-Capping' polymer was applied at a rate of 14 l (a.i) ha-1. The seeding rate trials were harvested mechanically using standard harvesting equipment and protocols.

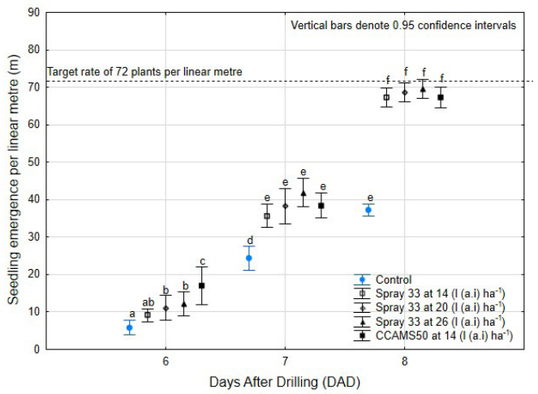
For replicated spinach Trial 1, at 7 and 8 DAD the 'Anti-Capping' polymer treatments were associated with 37 and 46%, uplift in emergence as compared with the Control respectively. Similarly, for replicated spinach Trial 2, at 8 and 9 DAD, the polymer treatments were also associated with a significant 46 and 17% uplift in emergence as compared with the Control.

For the seeding rate trials the yield results indicate that even with a 14% reduction in seeding rate (9.4 vs 8.1 M seeds ha-1), 'Anti-Capping' polymer application 1 DAD resulted in a 16.0% and 6.6% increase in yield for the 1st and 2nd seeding rate trials respectively.

These trials demonstrate that significant improvements in crop emergence, stand establishment and yield can be achieved through a single post-drilling application of anionic synthetic 'Anti-Capping' polymer. This has direct financial benefits to growers through reductions in seeding rates. Stabilising surface aggregates and preventing the formation of structural seals/crusts also has implications for both increased irrigation efficiency as well as reducing runoff and erosion risk.

ACKNOWLEDGEMENTS

The authors would like to thank Watts Farms Limited for the in-kind and technical support.



Replicated spinach Trail 1: Differences in spinach seedling emergence (plants per linear meter (n=50) between treatments

GT 08 - 224 - O

SENSOR SYSTEM FOR REAL-TIME SOIL SOLUTION MONITORING IN AGRICULTURAL SYSTEMS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Introduction:

The EU project FAMOSOS (Farm monitoring via real-time soil sensing) aims to develop a real-time monitoring system for measuring soil solution concentrations including nitrogen (ammonium, nitrate), pH, and dissolved oxygen, as well as soil moisture. This IoT system will consist of a wireless underground sensor network, composed of porous ceramic probes, combined with a micropump, an electrochemical sensor, and an antenna for wireless data transmission. The prototype beta-system is currently being tested in the laboratory and will then be used in situ in different cropping systems in Germany and Portugal. Data from the system will be used in the biophysical APSIM model to identify sustainable, climate-resilient agricultural practices.

Material and Method:

System Design: The FAMOSOS monitoring system consists of a wireless underground sensor network, composed of a porous ceramic probe, a piezoelectric driven micropump connected to electrochemical sensors, an electronic board, and an antenna for wireless data transmission. The sensor network is composed of a multi-function silicon-based sensor chip, which is integrated into a 3 D-printed microfluidic system connected to a metal based micropump which draws soil water via a suction cup and passes it directly over the sensor chip for measurement. An Analog Front End (AFE) platform, integrating a microcontroller unit (MCU) and a portable potentiostat, was designed to support both analog and digital sensors and control the micropump. The raw data from the sensors is collected by the AFE and converted into physical values by the microcontroller unit, and the data is then transmitted to a remote cloud via the LoRa communication (Figure 1).

Results:

A prototype (beta-system) was tested in the field at the AGROS cooperative in Argivai, Portugal. The beta-system was assembled on-site with the different parts provided by the partners. Water with different nitrate concentrations (5 and 50 ppm NO3) was applied to the soil surface, and the N concentrations in the soil water were measured by the electrochemical sensor. The beta system detected changes in nitrate levels over time providing real-time monitoring of nitrate in the soil solution (Figure 2).

Conclusion:

The system will be further developed into an automated sensor system, which enables quantification mineral nitrogen and other nutrient concentrations in the soil solution. The data will help to assess nutrient dynamics and potential losses via leaching, offering valuable insights for optimizing fertilizer management and improving soil health.

Keywords: soil monitoring, real-time, suction cup, piezoelectric micropump, electrochemical sensors, wireless underground IoT nodes.

ACKNOWLEDGEMENTS

The project is funded as an EJP-SOIL external project by the Finnish Ministry of Agriculture (4400T-0569), the French National Research Agency (ANR) under grant ANR-23-SOIL-0002-04, the German Bundesministerium für Bildung und Forschung.

Figure 1. Beta-system with the electronic board in a watertight casing, and the setup in the field

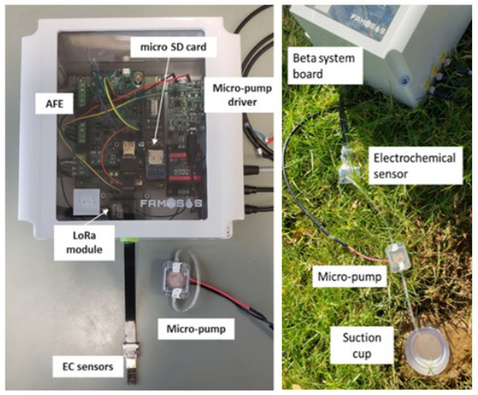
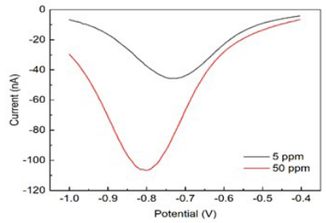


Figure 2. Electrical signal obtained by the beta-system in the field, with different N concentrations.





GT 08 - 276 - O

OPTIMIZING COWPEA GROWTH IN SANDY SOILS: EFFECT OF MULCHING, INOCULATION, AND SIMULATED DROUGHT ON SOIL WATER DYNAMICS AND PLANT DEVELOPMENT

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Sustainable agriculture in semi-arid regions like northern Namibia requires strategies that enhance crop performance under drought stress by improving the soil water dynamics. Mulching is one such strategy, but implementation is limited by the availability of conventional materials. Harvest residues are typically repurposed for livestock feed and therefore sparsely used in fields, while Namibia's efforts to combat shrub encroachment provides wood chips in abundance. Despite this, the effectiveness of these mulches, used individually and in combination on soil water dynamics and crop development under drought remains insufficiently understood. This study investigated the influence of agricultural practices of different types of mulching and rhizobial inoculation on soil water dynamics and subsequent developmental responses of greenhouse-grown cowpea (Vigna unguiculata) under simulated drought. A controlled pot experiment was conducted using mixed topsoil (0-10 cm) from Ogongo, Omusati Region, Namibia. Two irrigation levels were applied, water optimum at 45% and water stressed at 20% water holding capacity. Three treatments, 'Unplanted', 'Planted' and 'Planted + Inoculated' were tested. The rhizobial inoculate was applied directly to the soil before sowing for the 'Planted + Inoculated' treatment. Each treatment was divided into four mulching categories; unmulched, mulched with wood chips, wheat straw and a 1:1 combination of both. The experiment was conducted from seedling emergence through harvest. Soil water balance was assessed through measurements of evaporation, transpiration, total water input and water use efficiency. Phenological development was monitored through leaflet count, node number, stem height, root and shoot biomass, culminating in pod production. A composite developmental model was constructed to quantify phenological progress and predict delays in pod initiation under water stress. Results show that water stressed conditions significantly reduced crop development, but, mulched treatments notably buffered these effects. Among mulching types, the combined mulch of wood chips and wheat straw had the strongest positive effect. It reduced total water input by 14.9%, improved water use efficiency by 233.3%, transpiration by 262.9%, leaflet number by 55.0%, stem height by 11.7%, root and shoot biomass by 68.3% and 45.8% and harvest index from 0 to 3 compared to the unmulched treatment. Inoculation enhanced root to shoot biomass allocation, with the ratio decreasing by 80%, indicating a shift toward greater above ground investment under improved soil water balance. The model estimated a ~31-day delay in pod initiation for mulched, water stressed plants relative to water optimum conditions. These findings highlight mulching, as an effective strategy to improve soil water balance and reduce drought induced developmental delays in sandy soils and offers a practical solution for enhancing crop resilience in water scarce, semi-arid regions.



GT 08 - 296 - O

SOIL COVERS, SOIL DEPTH AND CLIMATE MODULATE THE CORRELATION BETWEEN SOIL MOISTURE AND SOIL TEMPERATURE IN AN ORGANIC VINEYARD: OBSERVATIONS DURING THREE YEARS AT NEAR REAL-TIME

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 05. SOIL HYDROLOGY & EROSION

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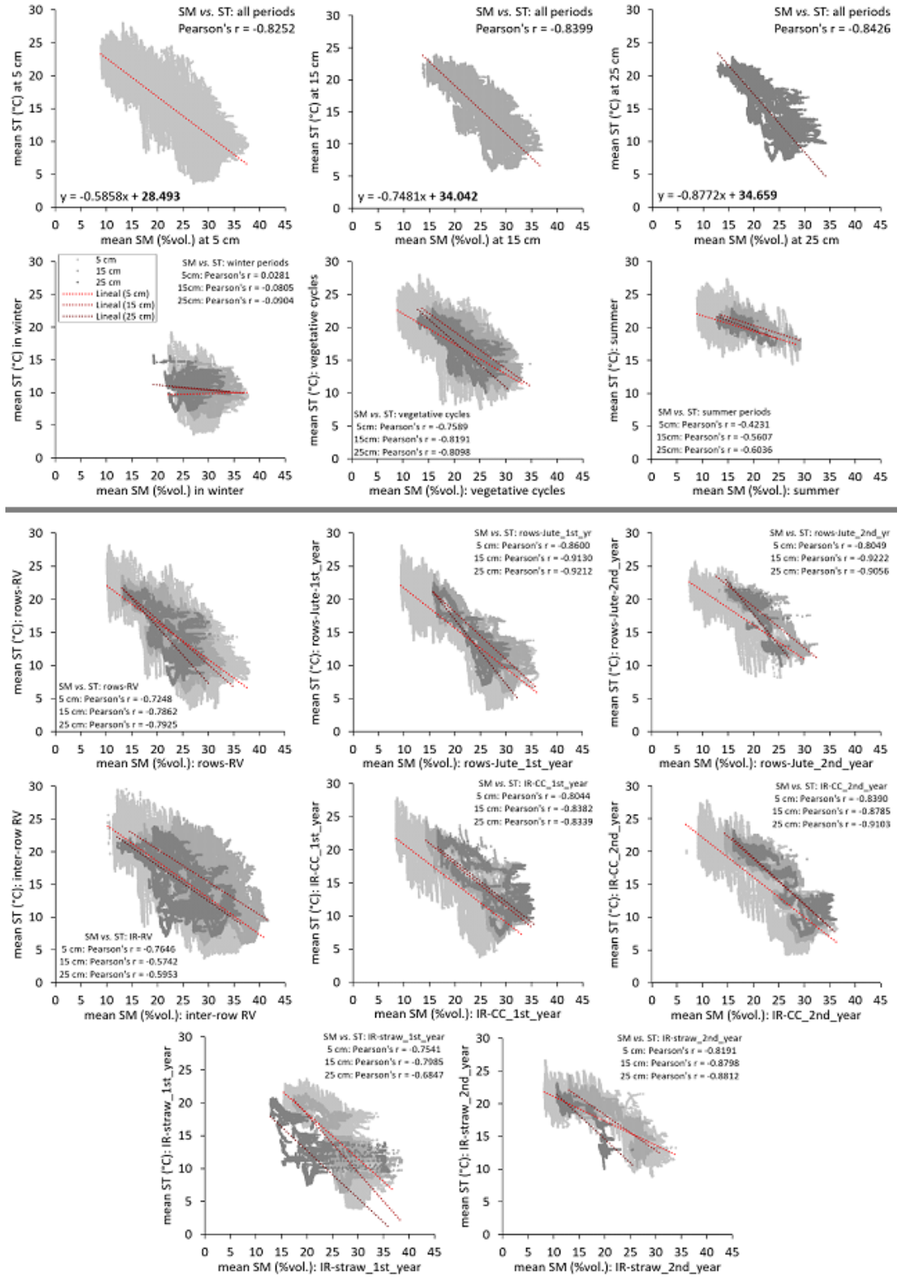
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Soil moisture (SM) and soil temperature (ST) are dynamic parameters influenced by climate, physical and chemical properties of the soil, topography, hydrology, vegetation, and land management. In permanent crops, soil covers reduce temperature variation and evaporation, and favour water infiltration. We hypothesize that different types of soil cover, both living (resident vegetation and permanent seeded cover crop) and inert (wheat straw and agrotextile of jute), modify the existing degree of relationship between these two soil parameters. To achieve this goal, an organic vineyard located in a humid climate was selected, allowing for the permanent presence of vegetation in the rows and inter-rows throughout the year. The field is small (592 vines in 1397 m2) and located at only 7 km from the coast of the Atlantic Ocean, in La Coruña province (NW Spain). The mean annual precipitation and temperature are of 1141 mm and 13.5 °C, with 21 days per year of frost. Vines are approximately 28 years old and trellised to a vertical shoot position (espalier system), with two branches per vine. The soil is classified as Cambic Umbrisol with a depth ranging between 35 to 50 cm. SM and ST were measured every 15 minutes over three years at various depths (5, 15 and 25 cm) by using twelve capacitance-based technology Sentek Drill & Drop Bluetooth® probes. Dataset started on February 26th, 2021, and ended on March 14th, 2024 (3 years and 17 days). In total, 7.686.144 values of SM and ST were recorded. A weather station was installed at the bottom of the field and values of rainfall depth, air temperature and humidity measured every 15 min during the same period. After analyzing the temporal evolution of the climatic and edaphic variables, as well as the tillage practices (mowing and plowing), sixteen different agro-hydro-thermic periods (AHTP) were identified. Considering the 3-year study period, correlations between SM and ST improved with soil depth, with a higher slope in the function of correlation, namely: Pearson's r = -0.8252, -0.8399 and -0.8426 at 5, 15 and 25 cm depth. Also considering the whole period, correlations were high during the vegetative period of the vines (r = -0.7589, -0.8191 and -0.8098 at 5, 15 and 25 cm), moderate during the summer (r = -0.4231, -0.5607 and -0.6036 at 5, 15 and 25 cm) and weak during the winter (r < 0.1 at the three soil depths). Rows with jute-1st year had the highest correlations at the three soil depths that decreased in the period with jute-2nd year and with resident vegetation. In the inter-row areas, the cover crop favoured higher correlations, both in the 1st and 2nd year, that decreased in the IR with straw (1st and 2nd year), and the lowest correlations appeared in the IR with resident vegetation. This study provides new data for soil science, both from an agronomic and soil physics perspective.

ACKNOWLEDGEMENTS

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Correlations between soil moisture and soil temperature at the three soil depths and considering the whole period, the vegetative, summer and winter periods, and the different living and inert soil covers evaluated during the study.



GT 08 - 300 - O

PROTEOMIC AND PHYSIOLOGICAL RESPONSES OF RICE SEEDLINGS TO CHLORTETRACYCLINE STRESS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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Chlortetracycline (CTC), a commonly used veterinary antibiotic, is extensively excreted through manure and accumulates in large quantities in livestock manure compost. In Korea, significant amounts of such compost are applied to paddy fields, raising concerns about potential antibiotic contamination in agricultural ecosystems[1]. Although CTC is known to negatively affect plant growth and physiological functions, research on its phytotoxic effects in rice (Oryza sativa L.) remains limited.

This study aimed to evaluate early-stage growth inhibition in rice caused by CTC toxicity and to investigate CTC-induced changes in protein expression using a proteomics approach. Rice seedlings were hydroponically cultivated for three weeks in Hoagland nutrient solution supplemented with CTC at concentrations of 0 (control), 1 mg/kg, and 5 mg/kg. Shoots and roots were harvested separately to analyze antibiotic accumulation, water content, nutrient uptake (Ca and Mg), and proteomic changes.

CTC accumulation in shoot tissues reached 0.7 and 12.9 µg/g in the 1 and 5 mg/kg treatment groups, respectively, while root tissues showed higher accumulation levels of 27.9 and 105.3 µg/g. In the 5 mg/kg group, moisture content and calcium and magnesium concentrations (0.93 and 1.70 g/L, respectively) were significantly lower than those of the control group (3.07 and 3.95 g/L, respectively). Proteomic analysis revealed upregulation of 30S and 50S ribosomal proteins, actin, ATP synthase, and chlorophyll a–b binding proteins in the 1 mg/kg group. In contrast, the 5 mg/kg treatment group showed increased expression of 40S and 60S ribosomal proteins, calcium-dependent protein kinase, and NADH dehydrogenase. These findings confirm the phytotoxic effects of CTC on rice and demonstrate that higher antibiotic concentrations adversely affect water retention and nutrient absorption.

This study highlights the ecological risks of veterinary antibiotic contamination in crop production systems and provides foundational data for developing management strategies to mitigate antibiotic pollution in agroecosystems.

ACKNOWLEDGEMENTS

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2020R1A2C1003313).

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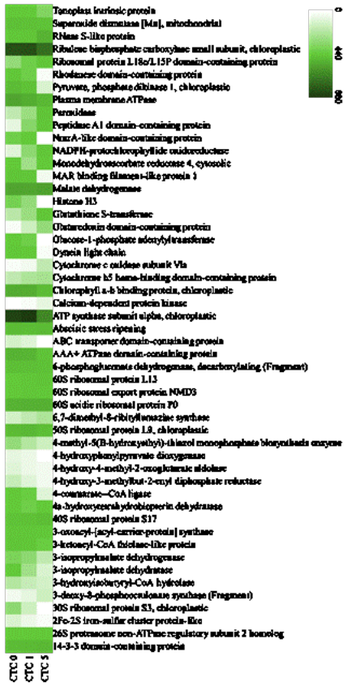


Fig. Heatmap of protein extracted from rice shoot

GT 08 - 329 - O

EFFECTS OF AFFORESTATION OF MARGINAL CROPLANDS ON SOIL PROPERTIES AND EVAPOTRANSPIRATION IN A SEMI-ARID ENVIRONMENT

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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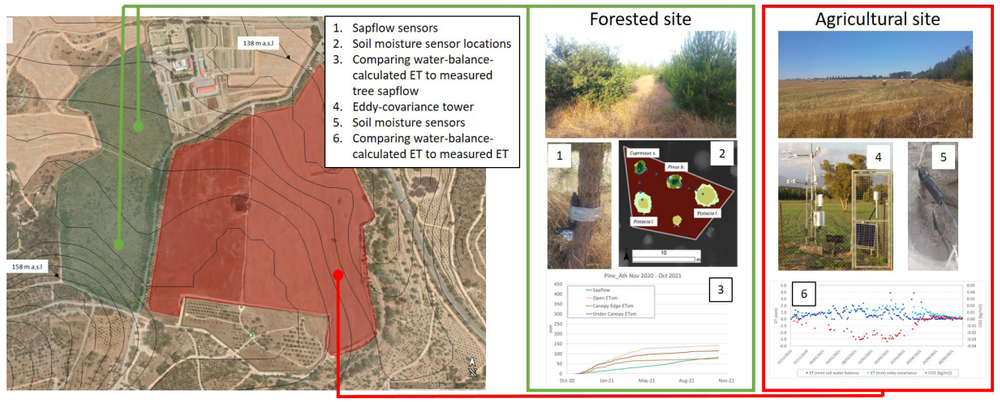
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Demand for afforestation has increased as trees store carbon and can mitigate rising atmospheric CO2 levels. In semi-arid environments, trees play an important role in the water cycle, an effect that is often overlooked. The overall objective of this research is to assess the effects of afforestation on soil and water in a semi-arid environment. The specific objectives are i) to assess differences in soil properties between agricultural and forested land (soil texture, bulk density, SOC, unsaturated hydraulic conductivity, electrical conductivity, pH); ii) to quantify evapotranspiration (ET) in agricultural (ETagri) and forested (ETfor) land using water balance calculations based on observed meteorological and soil moisture data; and iii) to compare water-balance-calculated ET with measured eddy-covariance ET in the agricultural (ETec) and tree transpiration in the forested site (Tfor). The study area is located in Athalassa Forest Park, Cyprus. The area has two contrasting land covers adjacent to each other: i) a rainfed agricultural site cultivated on a barley-legume rotation (20 ha) and ii) a forested crop-field, planted between November 2010 and February 2011 with mixed, indigenous, drought-tolerant trees and shrubs (10 ha). Both sites are located on similar sedimentary geologic formations, have an average slope of 5% and 315-mm average annual rainfall (30-year average). In November-December 2020, we installed an eddy-covariance tower, measuring CO2 and H2O fluxes and all energy balance components, together with soil moisture sensors at 10-, 30- and 50-cm depths (3 sensors each) in the agricultural site. In the forested site, we installed a meteorological station, 12 sapflow sensors (six Pinus brutia and six Cupressus sempervirens trees) and 66 soil moisture sensors placed under the canopy, at the canopy edge and in open areas (no tree canopy) at the same depths as agricultural field. Percussion drillings at three random locations per site showed similar soil depths of approximately 1 m for both sites. Soil texture was loamy sand for the agricultural site and sandy loam for the forested site (samples from 0-20 cm and 20-50 cm depths at three random locations per site). For the 2020-2021 crop season (sowing 17 November and harvesting 19 May), total precipitation was 171 mm, ETagri was 145 mm and ETfor was 157 mm. Precipitation for the 2021-2022 crop season (sowing 30 November and harvesting 7 June) was higher totaling 274 mm, ETagri was 175 mm and ETfor was 187 mm. During dry periods, ETagri was less than ETec, and ETfor was less than Tfor, indicating possible contributions of dew or uptake of water below the 60-cm soil depth. Afforested land showed slightly higher ET than cropland.

ACKNOWLEDGEMENTS

This research has received financial support from the PRIMA MED (2018 Call) SWATCH Project and the Water JPI (Joint Call 2018) FLUXMED Project, both funded through the Cyprus Research and Innovation Foundation.





GT 08 - 352 - O

SOIL CULTIVATION METHODS IN SLOPED VINEYARDS: BALANCING PLANT HEALTH, SOIL MOISTURE, AND GHG EMISSIONS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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This study aimed to assess the impact of inter-row soil management practices on soil moisture dynamics, plant health, and greenhouse gas (GHG) emissions in an organic vineyard. Two inter-row management treatments were compared: (i) a transition from shallow tillage to perennial cover cropping (CC), and (ii) permanent grass cover (GR). Measurements were conducted at upper, middle, and lower slope positions (~8% incline) to evaluate spatial variability. Soil water content (SWC) was monitored at depths of 15 and 40 cm, alongside plant health indicators including the Normalized Difference Vegetation Index (NDVI), Photochemical Reflectance Index (PRI), the fraction of absorbed Photosynthetically Active Radiation (fAPAR), and Leaf Area Index (LAI). In parallel, GHG emissions (CO2 and N2O) were measured to investigate the influence of cultivation method and slope position on emission levels during the first year of the study (i.e., tillage). Our results showed that the CC treatment significantly increased average SWC compared to GR ($p < 0.05$), particularly benefiting plant vigor, as reflected in higher LAI values ($p < 0.01$). However, continuous cover cropping also led to lower SWC in upper soil layers by the third year. NDVI, PRI, and fAPAR were significantly influenced by soil heterogeneity ($p < 0.001$), with moderate correlations observed between plant indices and soil parameters such as total nitrogen, pH, and SWC. GHG measurements revealed that the GR inter-rows emitted 2.9 times more CO2 and 6.1 times more N2O than the CC soils. Higher GHG emissions were associated with soils maintaining greater water content over time, with emission rates varying notably by slope position due to differences in soil physical and chemical properties. Overall, while perennial cover crop management supports improved plant health and water retention, it may also elevate GHG emissions. These findings highlight the importance of adapting soil management practices to local slope conditions and climate conditions to balance ecological benefits and environmental impacts in vineyard systems.

ACKNOWLEDGEMENTS

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GT 08 - 452 - O

INFLUENCE OF INCREASED FRESHWATERS BROWNING ON IRON PLAQUE FORMATION IN HYDROPHYTES

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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To survive anoxic soil conditions, flood tolerant species (hydrophytes) acclimate by forming root aerenchyma to facilitate oxygen diffusion from leaves to roots. Some oxygen diffuses into the anoxic rhizosphere by root radial oxygen loss (ROL), where soluble Fe(II) may undergo oxidative precipitation forming a reddish coating of Fe ox(hydrox-)ides on the root surface called iron plaques.

Global warming, hydrological and land-use changes are intensifying the browning of freshwaters in the northern hemisphere. The brownification phenomenon is caused by an increased coloured dissolved organic matter (cDOM) absorbing strongly in the PAR spectrum, which seems also related to an altered Fe cycle.

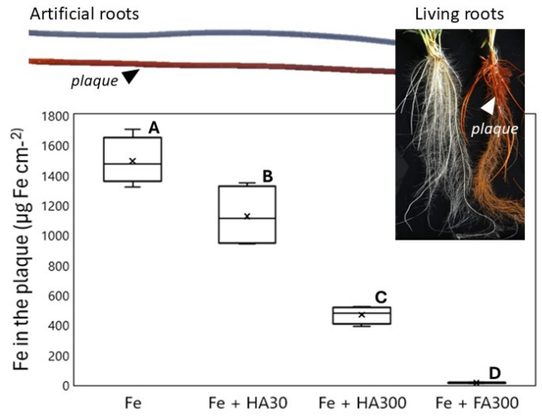
This work aimed to evaluate the possible impact of increasing concentration of humified organic matter (HS), the most active fraction of cDOM on the formation of iron plaques.

Tests were carried out on both artificial and living roots, referring to silicone tubes and Phragmites australis respectively. Artificial roots or 6-week old plants grown in hydroponics were immersed in a hypoxic solution containing 0, 30 or 300 mg L-1 of HS (standard HA e FA), without or with 2 mM Fe(II). Exposure time for plaque formation was about 2 weeks in the case of artificial roots and 3 days for plants. The effects of HS on iron plaque formation were evaluated by: i) daily measurements of Eh, pH, dissolved Fe(II) in the solution, ii) sampling of silicon tubes/roots during plaque formation and at the end of the experiments, with quantification of plaques by the dithionite-citrate-bicarbonate method; iii) collecting O2, pH and Eh profiles from the root surface to the solution, using microsensors.

In both artificial and living roots, the presence of HS delayed and inhibited the formation of the Fe plaques, because complexation enhanced Fe(II) solubility. In fact, the Fe(II) concentration in the solution decreased faster in the absence of HS, reaching almost null values after 6-7 days. FTIR analysis of the formed plaques showed that the main mineral form of iron was goethite. Interestingly, the presence of Fe plaques seemed to inhibit root ROL and affected the pH gradients in the surrounding of roots, with a buffering effect given by the presence of HS.

ACKNOWLEDGEMENTS

The project leading to this application has received funding from the EMBO Scientific Exchange Grant No 9028.



Effect of humified organic matter on root iron plaque formation in artificial and living roots. Fe stands for Fe(II) addition of 2 mM, HA for humic acid, FA for fulvic acid and 30 or 300 refer to the concentration expressed in mg/L.



GT 08 - 496 - O

SOIL PROPERTIES ARE DRIVERS OF BROAD-SCALE FOREST VEGETATION VARIATION

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 02. SOIL PHYSICAL CHEMISTRY

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The objective of this study was to identify the soil characteristics that explain the composition of the understorey forest vegetation in Finland. Relationships between forest vegetation and chemical and physical properties of the soil as well as stand characteristics were studied using global non-metric multidimensional scaling (GNMDS). The dataset consisted of 490 sampled plots on mineral soils throughout Finland. The plots are sub-set of the systematic network of permanent forest monitoring plots established by the National Forest Inventory in 1985-1986. The effects of soil variables (eg. nutrient, C, soil pH, CEC, soil texture) of the organic layer and mineral soil layers and some other environmental variables were evaluated by analysing their covariation with principal variation of vegetation. Of all tested nutrient variables and other soil characteristics, C/N-ratio and concentrations of some individual main soil nutrients had the highest correlation with understorey vegetation. In general, variables of the organic layer showed higher maximum correlations with vegetation than those of the upper mineral soil layers. Results indicated that resource gradients, i.e. the major soil nutrient concentrations, were more closely correlated with the compositional variation of the vegetation than physical soil factors or measured stand characteristics. These results have implication to selection of forest soil indicators that serve soil health monitoring and to analyses of soil responses to forest management practices.

GT 08 - 528 - O

UPTAKE AND ACCUMULATION OF MICROPOLLUTANTS CONTAINED IN IRRIGATION WATER OR BIOSOLIDS BY PLANTS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Due to the increasing water shortage, there is an effort to use treated wastewater for irrigation. Sludge from wastewater treatment plants (WWTPs) is often used as a source of organic matter and other nutrients. WWTP products contain a number of organic micropollutants. There is partial information on their behavior in soil, usually obtained under laboratory and greenhouse conditions. However, there is a need to obtain comprehensive information on their behavior, i.e. migration in soil and uptake by plants under real conditions. To assess the behavior of selected micropollutants (mainly pharmaceuticals) in soil-water-plant system, nine raised beds were installed in March 2021 near the outlet channel in WWTP for České Budějovice in the Czech Republic [1]. Two beds contain soil taken from the surface horizon of the Arenosol Epieuric and seven beds contain soil from the surface horizon of the Haplic Cambisol. In 2021, either corn or a mixture of different vegetables (lettuce, onions, carrots) were grown in the beds. Four treatments were carried out for maize grown in the Cambisol beds: A. irrigation with tap water (control); B. irrigation with wastewater; C. application of composted sewage sludge; and D. application of sewage sludge. Three treatments A, B and C were suggested for vegetables grown in the Cambisol beds and two treatments A and B for vegetables in the Arenosol beds. In 2022, two different mixtures of vegetables were grown in these beds. Potatoes, soybeans, and beans were planted in originally maize beds. Kohlrabi, parsley, radishes, and brussels sprouts were planted in the original vegetable beds.

Results from 2021 have been published by Kodešová et al. [1]. Composition and average concentrations of compounds in wastewater measured in 2022 were like those in 2021. Similarly, composition and concentrations of compounds in sludge and composted sludge measured in 2022 were like those in 2021. A larger spectrum of compounds was quantified in soils and in solutions leaked from the beds in 2022 than in 2021. Taken up and mobile compounds in plants were mostly accumulated in plant leaves. Concentrations were usually much higher than in other plant tissues. Mostly very low concentrations or no compounds were quantified in fruits (i.e., bean and soybean pods). Compounds of low mobility remained in soil and belowground plant tissues. The larger spectrum of compounds and highest concentrations were typically found in the periderm of carrot and parsley roots, followed by concentrations in the phloem and xylem. Low concentrations were recorded on the surface of potato tubers but not inside.

ACKNOWLEDGEMENTS

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GT 08 - 629 - O

CONTRASTING ADAPTIVE ROOT SYSTEM STRATEGIES OF QUERCUS ROBUR AND Q. RUBRA TO SEVERE DROUGHT DRIVEN BY PHOSPHORUS SUPPLY

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The interaction between soil nutrient availability and water deficit plays a key role in shaping plant adaptive responses, especially in forest ecosystems where invasive species challenge native biodiversity [1,2]. We investigated the morphological, biochemical, and metabolic responses to drought in Quercus robur (EO, native) and Quercus rubra (RO, alien) under contrasting phosphorus (P) availability. A greenhouse experiment was conducted with factorial combinations of water regime (well-watered vs drought) and P input, focusing on root ssystem morphological, biochemical and metabolic profiles.

Results showed that EO invested more in root biomass and nutrient acquisition under P addition, displaying a stronger metabolic plasticity compared to RO. In EO, P supply mitigated drought-induced suppression of primary (amino acids, organic acids) and secondary (isoprenoids, phenylpropanoids) root metabolism. Conversely, RO maintained a conservative growth strategy, with limited root plasticity and even exacerbated metabolic stress under combined drought and P addition. FTIR and UHPLC-QTOF-MS analyses confirmed that EO roots under high P and drought conditions retained metabolic activity aligned with enhanced stress tolerance, whereas RO showed reduced aromatic compound biosynthesis and saccharide accumulation.

Our findings highlight species-specific soil–plant–water interactions, suggesting that nutrient-driven metabolic modulation could enhance drought resilience in native species (Fig. 1). This mechanism may partially offset the competitive advantage of invasive trees in nutrient-poor, drought-prone environments, with important implications for forest management under climate change.

ACKNOWLEDGEMENTS

We thank “La Mandria” Natural Park for granting the permissions to conduct sampling within the park. Their support and cooperation were essential to this research. This study was carried out within the Agritech National Research Center and received funding from the NextGenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors’ views and opinions, neither the European Union nor the European Commission can be considered responsible for them. Open access publishing facilitated by Universita degli Studi di Torino, as part of the Wiley - CRUI-CARE agreement.

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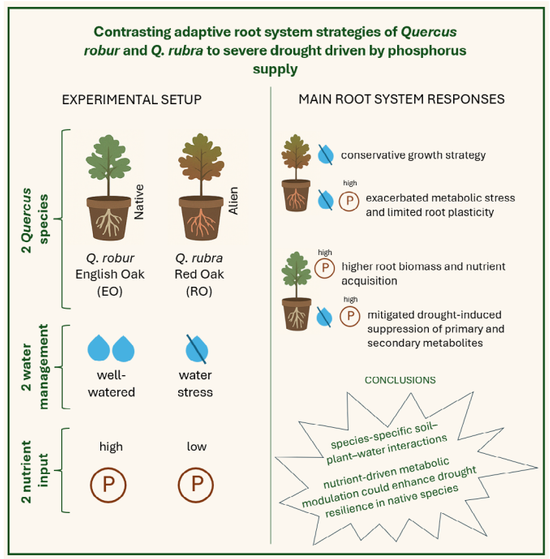


Figure 1. Graphical abstract

GT 08 - 655 - O

P CONCENTRATIONS IN SURFACE WATER SOURCES ADJACENT TO MAJOR CROPPING SYSTEMS ACROSS THE FRASER VALLEY, BRITISH COLUMBIA, CANADA

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil Phosphorus (P) loss from agricultural lands pose a significant risk to aquatic ecosystems, contributing to eutrophication particularly in regions with intensive livestock production. In the Fraser Valley, BC, long term over application of P as mineral fertilizer and manure, has led to considerable soil P accumulation. This study investigated the surface water P concentrations from ditches and streams adjacent to agricultural and livestock farms across three major agricultural areas: Agassiz, Chilliwack, and Abbotsford. Water samples were collected from nine sites between May 2024 and March 2025. At each site, one composite water sample was collected every 24 h, consisting of four sub-samples taken at 6 h intervals. Samples were analyzed for dissolved reactive P (DRP), particulate P (PP), and total P. Preliminary results show substantial temporal and spatial variation in P concentrations. Three of the nine sites exhibited notably higher PP and total P concentrations, while one site recorded higher DRP. Overall, DRP, PP, and total P ranged from 0 – 6.0 mg L-1, 0 – 94.5 mg L-1, and 0 – 132.1 mg L-1, respectively. There was a strong correlation (r = 0.94) between total P and PP, however no significant relationship of DRP with either PP or total P was found. The total P concentrations were higher than 0.01 mg L-1, threshold level to classify rivers or lakes into hyper trophic status, in majority of the samples. Water sampling will be continued until May 2026. Future analysis will explore the relationship between P concentrations in water with soil characteristics including environmental soil P loss indicators (degree of P saturation, water soluble P, and P saturation index) and management factors of the adjacent fields.

ACKNOWLEDGEMENTS

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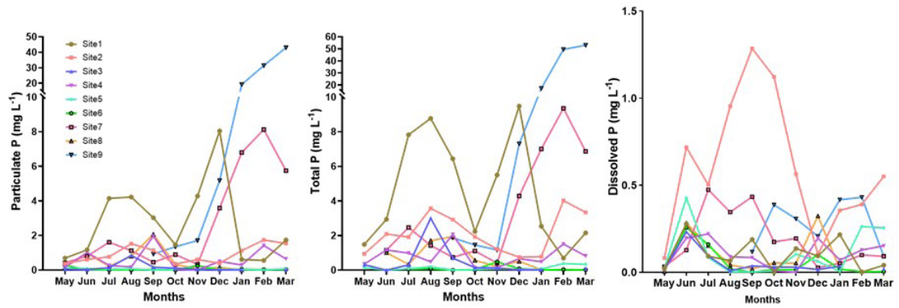


Figure: Monthly average (may 2024 – march 2025) Particulate phosphorus, total phosphorus and dissolve reactive phosphorus across nine sites in the Fraser valley, BC, Canada.



GT 08 - 737 - O

THE INTERPLAY BETWEEN DROUGHT AND PHOSPHORUS SCARCITY SHAPES RESILIENCE TO STRESS IN QUERCUS SPP. BY MODULATING METABOLOMIC PROFILES

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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The plant resilience to drought conditions is modulated by physiological and metabolic responses, including antioxidant metabolites accumulation. These mechanisms can be implemented by nutrient availability, especially phosphorus (P). In European mixed forests, native species with high resource demands often compete with more efficient alien species, whose advantage under abiotic stress can enhance their invasiveness. This study investigates how drought and P availability influence the resilience of two Quercus spp. differing in stress tolerance and resource use efficiency.

We set up a mesocosm experiment where the native Q. robur (EO) and alien Q. rubra (RO) species were grown under well-watered or drought conditions, with or without the addition of phosphorous (P). The leaf gas exchanges and stem water potential were measured, the leaves and soil were chemical characterized and the biosynthesis of metabolites was investigate with an omics approach.

During drought, the metabolism of P supplied EO shift toward the accumulation of phenylpropanoids, flavonoids, saikosaponins, mannitol, and long-chain fatty acids, which are compounds known for their antioxidant, osmoprotectant, and membrane-stabilizing functions. Conversely, RO plants exhibited a more conservative metabolic profile, with limited changes in response to P supply. Under P deficiency, RO accumulated secondary metabolites such as phenylpropanoids and alkaloids, highlighting its capacity to cope with combined nutrient and water stress.

Our results demonstrate contrasting adaptive strategies: EO is more susceptible to drought stress but P availability can shape its resilience, while RO maintains more stable physiological and metabolic functions, consistent with higher nutrient use efficiency.

GT 08 - 847 - O

INFLUENCE OF GRASSLAND LEGUMES ON NUTRIENT CYCLING IN SEMI-ARID GRASSLAND SOILS, AND INTERACTIONS WITH NUTRIENT LIMITATION.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Grasslands in semi-arid regions of sub Saharan Africa are highly important for food production and rural livelihoods. However, many grasslands are in a degraded condition, with intensification and climate extremes driving positive feedback loops of vegetation loss, erosion, soil degradation and reduced plant diversity, threatening productivity and drought resilience.

Restoration of semi-arid grasslands often focusses on conserving or re-seeding grasses with high grazing value. However diverse swards, particularly those containing legumes, have been shown in temperate regions to be more productive and resilient to drought, as well as promoting cycling and accumulation of nutrients and carbon [1,2]. Restoring soil functions such as nutrient cycling is key to enable successful re-vegetation of degraded grasslands [3]. Nitrogen-fixing legumes may be particularly important nitrogen-limited semi-arid grassland soils. Despite this, there has been little research on the influence of grassland legumes on the soil function, productivity and resilience of semi-arid African grasslands.

To address this gap, grass-legume mixes grown in soil from a semi-arid Kenyan grassland were compared with grass-only mesocosms, under both droughted and well-watered conditions. Grass aboveground biomass and root growth were greater in a native legume-grass mix than the control, while a non-native forage legumes did not increase biomass production. The effect varied between grass species. The benefits of legumes were resilient to moderate drought conditions. Soil nutrient levels were unaffected by the presence of the native legume, while nitrogen content of plant and root tissues did increase, reflecting the level of nutrient limitation in these soils relative to grass demand. Our findings suggest that legumes play an important role in the productivity and drought resilience of grasslands by partly mitigating nitrogen limitation.

To further investigate the influence of legumes on nutrient cycling, a litter decomposition experiment was established, comparing the impact of grass-legume and grass-only litters on soil nutrient levels and microbial activity. Since phosphorus (P) can be a key limiting factor on litter decomposition, the impacts of different litter mixes on both a high P soil and a low P soil are assessed. We will be presenting the results of this study alongside those from the mesocosm experiment, giving insights into the interactions between plant diversity, nutrient limitation and soil function.

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GT 08 - 864 - O

MOISTURE MATTERS: SOIL CHEMISTRY AND MICROBIAL DYNAMICS IN COWPEA RHIZOSPHERES

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 04. SOIL BIOLOGY

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Cowpea (Vigna unguiculata) is a vital leguminous crop in water-limited regions, yet the role of soil chemistry in shaping its rhizosphere microbiota remains underexplored. This study investigates how soil physico-chemical parameters influence microbial communities in cowpea rhizospheric soils. Samples were collected from three cowpea fields in the Trás-os-Montes region (Portugal) with differing soil moisture contents: low (2.4% w/w), moderate (3.9% w/w), and high (10.5% w/w). A culture-dependent method coupled with molecular identification (16S rRNA for bacteria, ITS for fungi) was used to characterise microbial communities. Soil pH, electrical conductivity (EC), organic matter (OM), and nutrients were also analysed. Relative abundance profiles, PERMANOVA, and Spearman correlations assessed shifts in community structure and environmental associations. Microbial patterns varied markedly with soil moisture. Bacterial communities in low-moisture soils were dominated by stress-tolerant taxa with reduced functional diversity, while moderate and high-moisture soils supported more taxonomically and functionally diverse groups. Fungal communities under low moisture showed increased saprotrophs and pathogens; moderate moisture favoured symbiotic fungi; and high-moisture soils displayed the most balanced trophic structure.Results indicated that OM was the most influential factor shaping bacterial communities, explaining 26.64% of the variation of their composition while EC significantly influenced fungal trophic modes (25%). Correlation analyses reinforced these trends: beneficial bacterial guilds (e.g., plant-growth promoters, biocontrol agents) were positively associated with OM and EC, whereas plant-associated bacteria were negatively correlated with several nutrients, indicating adaptation to low-input soils. Fungal pathogens were strongly linked to high Ca, Mg, and CEC, while yeast symbionts thrived in N-rich, conductive soils. Wood saprotrophs preferred low-EC, low-P environments.

These findings demonstrate that microbial communities in cowpea rhizospheres respond not only to moisture availability but also to distinct chemical drivers. Organic matter and electrical conductivity emerge as key regulators of microbial composition and function. This knowledge supports more targeted, microbiome-informed soil management strategies for improving cowpea resilience in variable environments.

KEY WORDS:

Vigna unguiculata, Microbial diversity, Microbial composition, Trophic groups, Ecological guilds, Metabolic functions

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GT 08 - 50 - F + P

PEROXIDASE ACTIVITY OF FRESH APPLE ROOT: A NOVEL APPROACH OF RESORUFIN-BASED MICRO-ZYMOGRAPHY

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Root-associated enzymes are crucial for plant defense against soil-borne diseases. While soil zymography has been widely used to visualize hydrolytic and oxidative enzyme activities, microzymography remains a novel approach, primarily applied to hydrolytic enzymes. Here, we introduce Amplex Red-based microzymography for detecting rhizosphere peroxidase activity with high spatial and temporal resolution. Soil zymography was used to visualize chitinase activity in the rhizosphere of apple seedlings (Malus domestica) grown in healthy or apple replant disease (ARD)-affected soil. Based on chitinase hotspots, we selected root regions for microzymography and applied Amplex Red with the presence of H2O2 under the fluorescence microscopy to assess peroxidase activity dynamics. This method provided high sensitivity for detecting peroxidase activity. Roots with long root hairs exhibited 78% higher peroxidase activity, with a distinct activity zone extending 200 µm around root hairs. Peroxidase activity within 300 µm of the root tip (calyptra) was 1-fold higher compared to apical meristem, and increased over time. Roots from ARD-affected soil showed 50%–92% higher peroxidase activity than those from healthy soil, supporting a dual-defense mechanism integrating hydrolytic (chitinase) and oxidative (peroxidase) pathways. This study creatively applied Amplex Red in microzymography, enabling in situ, high-resolution peroxidase activity detection. By linking hydrolytic and oxidative enzyme activities, it provides new insights into rhizosphere biochemical defenses against ARD.



GT 08 - 345 - F + P

BARE SOIL MOSAICKING OPTIMISATION FOR SOIL ORGANIC CARBON PREDICTION IN CENTRE-VAL DE LOIRE (FRANCE)

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil organic carbon (SOC) is essential for soil health and carbon cycling. Although remote sensing provides an efficient way to monitor SOC, its accuracy is often affected by vegetation cover, crop residues, and soil surface conditions, addressing the importance of bare soil composites. In this study, we used a 7-year Sentinel-2 time series over the Centre-Val de Loire region (39151 km²) in France to generate bare soil mosaics and examined the effects of different spectral index thresholds, seasons, soil moisture (SM) conditions, and soil types on SOC prediction [1, 2, 3]. The performance of SM indices, serving as a proxy, was evaluated using a 7-year time series of Sentinel-1 derived SM products [4].

Our results showed that, using late summer-early autumn imagery improved prediction accuracy to some extent, where the SM index served as an effective filter. In addition, modeling SOC separately for each soil type led to a substantial performance improvement. These findings contributed to optimising bare soil mosaicking and SOC mapping, highlighting the importance of using SM indices as a proxy and incorporating soil types into modelling.

The authors would be pleased to contribute to either Session 8.1 or Session 14.1.

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GT 08 - 650 - F + P

SOIL-PLANT-WATER DYNAMICS IN VINEYARDS OF VOLCANIC AREAS IN SOUTHERN ITALY: A THREE-YEAR STUDY OF THE 'PIEDIROSSO' CULTIVAR IN THE CONTEXT OF CLIMATE CHANGE.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The improvement of wine production and quality represents a sector of international strategic importance. World wine production in 2024, excluding juices and musts, is estimated at 225.8 mhl (million hectolitres) (OIV, 2025). The changing environmental constraints require even more adaptations of vineyard management techniques, as many wine-producing areas fall into environments affected by water deficit. This is the case of the volcanic environment at the footslope of the Somma-Vesuvius Volcano Complex (Campania Region, southern Italy). In the framework of the CISAV project (financed by the University of Naples Research Funding - FRA), drip-irrigation treatments (from 2021 to 2023) were carried out from veraison to vintage. The targeted grapevine cultivar was the Piedirosso (Vitis vinifera sp), a local variety. After a preliminary assessment of spatial homogeneity of the vineyard soils, by EMI and ɣ-ray proximal sensors, a pedological survey was carried out by analyzing 3 soil profiles. Irrigation treatments were monitored by matric potential and water content sensors at different depths. The three years of experiments exhibited distinct VPD (vapor pressure deficit) and monthly rain deficit patterns, resulting in critical differences in vine stress. The irrigation treatments, based on the soil sensors' response, were managed to obtain decreasing water stress conditions in the 3 different years. The stomatal conductance (gs) and the midday stem water potential (MSWP) were measured on the vines of the control area and the treated ones, before and after the start of the irrigation period until harvest. Data showed significant differences in vine response, with an improved health status of the plants during the irrigation treatments. Concerning grape maturity and enological traits at harvest, after the first year, a few variables (i.e., anthocyanins and tannins in skin) revealed to be affected by the treatments, while decreasing the water deficit, increasing the effect on grape characteristics (i.e., berry weight and volume, total soluble solids, pH, total acidity) and enological parameters (i.e., color intensity, hue, anthocyanins, tannins in skin, IRPs-total phenolics). Factorial ANOVA, analysing both the treatment and the vintage effects on grapes, highlights a higher influence of the climatic conditions than the treatments on the grape maturity and the main phenolic compounds content. In view of climate change and to face extreme climate variability, this study demonstrates how targeted irrigation strategies can mitigate water stress on Piedirosso grapevines and ensure the achievement of premium quality parameters required by the wine production regulation of the 'Lacryma Christi del Vesuvio DOC'. The future of Mediterranean viticulture depends on adaptive water management to preserve typicality and excellence.

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GT 08 - 825 - F + P

SENSOR SET DEVELOPMENT FOR SMART IRRIGATION

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The aim of the project is to develop a market-oriented, data driven precision irrigation control system, which will integrate the traditional field soil survey knowledge, GIS and remote sensing tools, smart sensing and monitoring systems with data analysis and processing algorithms. This decision supporting system will be harmonized with adapted tillage solutions to control the combined irrigation and nutrient supply technology adjusted to the local conditions.

The specific goal is to develop a soil information – static and dynamic soil property - based agricultural decision support ICT platform that can be integrated with the existing precision agriculture technology. This system is capable of optimizing the production system, the nutrient and water supply, increase the profit and decrease the environmental pressure by monitoring the soil conditions and its changes due to the production. The major contribution of this project to the sustainability of agro-food production chain is the data based ICT platform and sensor set development. The elements of the system are proximal and remote sensing, soil monitoring, vegetation monitoring, agrotechnology and agrometeorology. These different data sources will be channelled into a big data platform processed and analysed by artificial intelligence. The suggested platform can also integrate all production machinery produced log datasets.

A „mid-cost" specific sensor set was designed and developed to support soil and microclimate data collection. The integrated sensor set includes a GPS, volumetric soil moisture in four depths, electric conductivity, redox-potential, soil and air temperature and humidity. Additional air temperature and humidity sensors can be installed within and over the vegetation canopy. The sensors are deployed to all representative geomorphological and soil units. The hourly measurements is sent locally to a Lorawan gateway, which sends the data using GSM communication to the data server. Digital soil mapping tools are employed to map the measured parameters on the field.

Our solution would join the precision irrigation technology to general soil and vegetation monitoring. The system will provide data on the vegetation condition and on the water and nutrient supplying capacity and condition of the soils. It is also a valid tool to measure the impacts of the applied technology on the current soil environment. The data will be structured for further interpretation by experts and by artificial intelligence tools. The system control would ensure the optimal supply of chemicals and water in order to avoid soil and water degradation like, nutrient loss due to water stagnation and anaerobic conditions, leaching of the nutrients into the ground water, soil and water pollution or salinization.

GT 08 - 13 - P

EFFECT OF SHRUB ROOT SYSTEMS AND THEIR EXUDATES ON SOIL BIOCHEMISTRY IN PINE STANDS IN TEMPERATE CLIMATE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The objective of our research was to investigate how the inclusion of selected shrub species in monoculture pine stands influences soil properties. We hypothesized that shrubs, through their root systems and exudates, significantly affect the physicochemical and biological characteristics of soils. The study included four experimental plot variants: a monoculture pine stand, a pine stand with rowan admixture, a pine stand with alder buckthorn admixture, and a pine stand with European hazelnut admixture. The research focused on examining the role of the root systems of selected shrub species in shaping soil properties. We assessed the morphological traits of the roots, their growth increment, and the amount of carbon released through root exudates. To evaluate soil biochemical status, we analyzed extracellular and intracellular enzyme activities and microbial biomass. Our findings highlight the substantial influence of root morphology and exudates on soil enzymatic activity. Multiple regression analysis revealed that root increment, specific root area (SRA), and the number of root tips are key factors shaping enzymatic activity. Strong correlations were observed between enzyme activities (both extracellular and intracellular) and root exudates. European hazelnut released the highest amounts of carbon, regardless of the sampling date. Shrubs in pine monocultures create "fertile islands," characterized by improved soil properties, which are crucial for maintaining soil health. These results demonstrate that shrubs can be valuable components of forest ecosystems, positively influencing soil properties and potentially enhancing the stability of forest stands.

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GT 08 - 16 - P

INFLUENCE OF DIFFERENT SOIL GENESIS ON PRODUCTIVITY TRAITS OF ALFALFA (MEDICAGO SATIVA L.) UNDER LITHUANIAN CONDITIONS.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The influence of soil types on fresh, dry and seed yields, stem number and height of plants were evaluated under Lithuanian climate conditions in the study period 2019–2024. In 2018, 2020 and 2022, alfalfa was sown on two experimental sites of the Lithuanian Research Centre for Agriculture and Forestry. Experimental site I was installed in the Vėžaičiai Branch in the western part of Lithuania (55°70´ N lat., 21°49´E long.), and experimental site II was installed in the Institute of Agriculture in the central part of Lithuania (55°23N´lat., 23°51´E long.). The soil type of experiment site I and II was Retisol and Cambisol, respectively. The experimental design of alfalfa was a randomized complete blocks design with six replications. The results showed that soil pH, mobile aluminium, precipitation, temperature and soil moisture significantly influenced the fresh matter yield, dry matter yield ($P < 0.0000$), stem number and plant height ($P < 0.0001$). Precipitation, temperature and soil moisture had significant influence on seed yield ($P < 0.0000$). In Retisol, the seed yield of alfalfa was 2.2-fold higher in 2019 than in 2020. The plant height and stem number were 1.7-fold and 1.2-fold higher in 2022 than in 2021, respectively. In 2024, the seed yield was 1.7-fold higher than in 2023. The correlation coefficient was determined between soil moisture and fresh matter, dry matter and seed yields and the stem number range, from r = 0.361* to r = 0.524**. The correlation coefficient was determined between soil pH and mobile Al (r = -0.882**), between soil pH and seed yield (r = 0.403**) and between mobile Al and seed yield (r =-0.398**), between precipitation and all productivity traits, ranging from r = 0.34* to r = 0.799** and between temperature and all productivity traits, ranging from r = 0.388** to r = 0.783**. In 2021, the dry matter yield and stem number in Cambisol was 1.2-fold higher than in 2022. In 2023, the dry matter yield was 1.2-fold higher than in 2024, but the height of plants was 1.1-fold higher in 2024. The correlation coefficient was determined between soil pH and dry matter yield r = 0.433**, between soil moisture and fresh and dry matter yields, r = 0.494** and r = 0.542**, respectively. The correlation coefficient was determined between precipitation and dry matter yield, fresh matter yield and stem number, ranging from r = 0.332* to r = 0.716**, between temperature and stem number, dry matter yield and seed yield, ranging from r = 0.405* to r =0.768**. The diversity of alfalfa plants was significantly higher by seed yield, height of plants and stem number in Retisol compared to Cambisol.

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GT 08 - 31 - P

A MODEL STUDY ON NITROGEN AND WATER STRESS EFFECTS ON BARLEY: YIELD POTENTIAL AND YIELD GAP

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Barley (Hordeum vulgare L.) holds a significant position among cereals, serving an essential role in both animal feeding and human consumption (e.g., in malting). As one of the oldest cultivated crops, its adaptability allows it to thrive in both high-input and low-input agricultural systems, making it a versatile and resilient crop [1].

This study aimed to examine the effects of N and water stress on barley grown in marginal soils through field trials and the AgroC model. Field experiments with the spring barley variety KWS Fantex were conducted from 2020 to 2022 in eastern Lithuania (Figure 1).

The AgroC model [2] was calibrated using data from 2020 (characterized by normal temperature and precipitation) and 2022 (hot and wet), then validated using data from the 2021 growing season (also hot and wet). The model accurately reproduced barley leaf, stem, storage organ, and grain development throughout the growth period. Additionally, the simulated leaf area index, developmental stages, and soil water content (from 15 cm to 110 cm depth) showed good agreement with the measured data. After validation, the AgroC model was used to simulate barley growth and to assess yield potential as well as yield gaps caused by water and N stress. Potential grain yields ranged from 4.8 to 6.02 t ha-1, with yield losses up to 54.4% and 59.2% due to N and water shortages, even with the N100 treatment (100 kg N ha-1 yr-1). A synthetic case study varying N fertilization from zero to 200 kg N ha-1 yr-1 showed that increasing N can still enhance yield, but optimal rates depend on climatic conditions, leading to uncertainty in fertilization recommendations. The study underscores the importance of integrating advanced modeling techniques with sustainable agricultural practices to boost yield potential and resilience in marginal soils. Incorporating remote sensing data to capture soil and crop variability is recommended to improve simulation accuracy, contributing to sustainable agriculture strategies in the Baltic-Nordic region.

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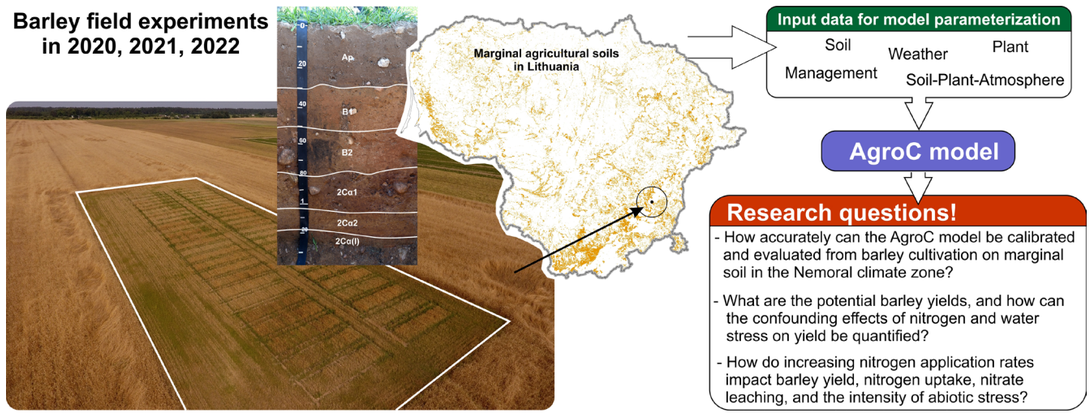


Figure 1. Location of the barley experimental sites.

GT 08 - 156 - P

REAL-TIME MONITORING OF PLANT WATER UPTAKE BASED ON ROOT–SOIL DIELECTRIC RESPONSE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 02. SOIL PHYSICAL CHEMISTRY

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Background and aims: Measurement of root dielectric response is a useful non-destructive method for assessing root growth and function. Previous studies have tracked root development throughout the plant growth cycle by single-time electrical measurements taken repeatedly. However, it is known that root conductivity and uptake activity can change rapidly, coupled with the day/night cycles of photosynthesis and transpiration rates. Therefore, low-frequency dielectric monitoring of intact root–substrate systems at minute-scale temporal resolution has been tested.

Materials and methods: A customized impedance measurement system was developed and applied in a laboratory environment. Electrical capacitance, conductance and dissipation factor were measured at 1 kHz AC frequency for 144 hours in potted maize, cucumber and pea plants grown under different light/dark and temperature conditions, or subjected to progressive leaf excision or decapitation. Leaf chlorophyll concentration, PSII quantum efficiency (Fv/Fm) and stomatal conductance were also measured to evaluate the stress response.

Results: The data series of electrical capacitance and conductance showed significant 24-hour seasonality associated with the light/dark and temperature cycles applied. This was attributed to the diurnal pattern of whole-plant transpiration (based on in situ stomatal conductance measurements using a porometer), which is closely related to integrated root water uptake. Capacitance and conductance decreased during the 6-day dark treatment, and decreased proportionally with increasing defoliation levels, probably due to the loss of canopy transpiration caused by dark-induced senescence or removal of leaves. The dissipation factor showed a decreasing trend for plants exposed to 6 days of darkness, whereas it was markedly increased by decapitation, indicating altered root membrane structure and permeability, and a modified ratio of apoplastic to cell-to-cell water and current pathways.

Conclusions: Real-time, single-frequency impedance measurement of the intact root system was an efficient way to track integrated root water uptake, including diurnal cycles, and stress-induced changes in situ. It was also shown that the dielectric response was mainly originated from root tissue polarization and current conduction, and was influenced by the actual physiological activity of the root system. Dielectric measurement on fine timescale, as a diagnostic tool for monitoring root physiological status and environmental response, deserves future attention.

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GT 08 - 163 - P

INFLUENCE OF MORPHOLOGICAL HILLSLOPE FEATURES INK DISEASE OF CHESTNUT GROVE IN NORTHERN APENNINE MOUNTAINS (ITALY): A SOIL PERSPECTIVE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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Ink disease is one of the most serious diseases of sweet chestnut (Castanea sativa) groves in Europe because of its rapid increase in incidence and geographic distribution. The soil-borne Phytophthora cambivora (Petri) and Phytophthora cinnamomi (Rand) are considered the two species of the oomycete genus responsible for ink disease. Despite soil conditions significantly influence the severity of pathogenic attacks and, more in general, the soil microbial community and its functionality, there is still scarce knowledge about the relationship between pedogenetic processes and soil microbial community. The present study aimed to assess whether the pedogenetic processes related to soil morphology influence: 1) the microbial communities in both topsoil and subsoil horizons, and 2) the chestnut ink disease development. In a Castanea sativa grove in Northern Italy, three soil profiles were dug close to ink diseased plants (INK1) and healthy plants (INK2 and INK3), and each soil horizon evaluated for its properties. The experimental design was carried out along a 60 m transect where INK1 was located at the lowest slope position (978 m a.s.l.) and INK3 at the highest one (998 m a.s.l.). In addition, soil profiles of INK1, INK2 and INK3 had a slope gradient of 3, 9 and 30 %, respectively. The investigated soils were classified as Luvisols with a more intense accumulation of clay in the whole soil profile of INK1 due to its footslope position and gentle slope gradient. Such pedogenetic process increased the saturated hydraulic conductivity and the wilting point, which might promote the water accumulation within the deeper soil horizons of INK1. These conditions are conducive to the survival and proliferation of Phytophthora in INK1. Conversely, the higher slope gradient in INK2 and INK3 allowed the downhill transport of clay by water preventing ink disease development. The presence of ink diseased plants in INK1 might have favoured the spread of ectomycorrhizal fungi in the subsoil horizons of INK1 since the recognized role of such fungi to offer protection against Phytophthora infections. In addition, pathogen infections are known to increase the carbon-to-nitrogen ratio of the soluble organic fraction. Therefore, the relative lower amount of labile nitrogen in INK1 than in INK2 and INK3 might have favored contact and medium-distance exploration types of ectomycorrhizal fungal community which are more efficient at acquiring labile nitrogen. In addition, the relative lower amount of labile nitrogen in INK1 than in INK2 and INK3 might also explain the absence of nitrifying bacterial taxa like Nitrospirota. Finally, such study highlighted the pivotal role of soil processes (i.e., clay and water transport) to shape the soil microbial community and soil-borne pathogens because of the changes of edaphic properties.

ACKNOWLEDGEMENTS

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GT 08 - 207 - P

WATER LEVEL MORE THAN EARTHWORMS IMPACT RICE GROWTH AND PRODUCTIVITY. A LABORATORY EXPERIMENT.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 04. SOIL BIOLOGY

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Rice (Oryza sativa L.) is a vital staple food crop in Southeast Asia, contributing to the food security of the population, as well as rural livelihoods and national economies. This study investigates the influence of the subaquatic earthworm species Glyphidrilus papillatus (Michaelsen, 1896) on soil properties and rice physiology in Northern Vietnam, specifically focusing on rice cultivation at three distinct water depths: 5 cm above the soil surface (HIGH), at the soil level (ZERO), and 5 cm below the soil surface (LOW). Our findings indicate that water levels significantly affect earthworm activity, with the lowest activity observed at the shallowest water depth, as evidenced by reduced pore production in the soil and fewer casts on the surface. While earthworms are typically associated with enhanced soil fertility, this study did not confirm this relationship, except for a noted increase in potassium levels within earthworm casts at the lowest water level (LOW). Consequently, despite the substantial reorganization of soil structure facilitated by earthworms, no significant interactions were found between earthworm presence and rice biomass, physiological parameters (such as leaf stomatal conductance to water vapour, chlorophyll content, and maximum quantum yield of PSII), or overall yield. Conversely, this research highlights the critical role of water depth in influencing both earthworm activity and rice development. It underscores the necessity of considering additional ecological factors, such as carbon dynamics, greenhouse gas emissions, and plant resilience to environmental stressors, including pest presence and drought.

KEYWORDS

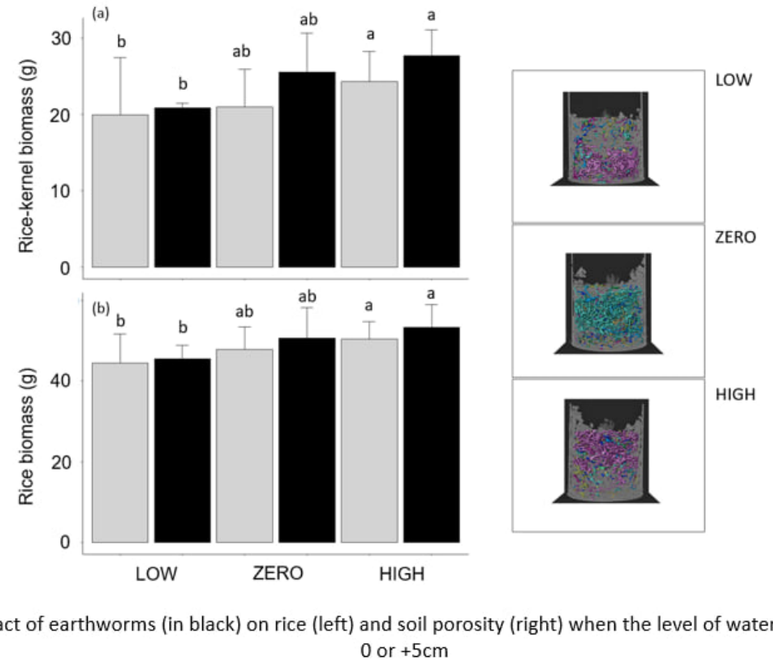
Glyphidrilus papillatus, soil saturated conditions, bioturbation, porosity, nutrient cycling, rice physiology.

ACKNOWLEDGEMENTS

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Impact of earthworms (in black) on rice (left) and soil porosity (right) when the level of water is -5cm, 0 or +5cm

GT 08 - 415 - P

USING MACHINE LEARNING TECHNIQUES TO ASSESS GRAPEVINE VEGETATION HEALTH WHILE ADAPTING SATELLITE VEGETATION INDICES

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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Vegetation indices derived from remote sensing (RS) provide rapid and multifaceted insights into vegetation health and condition. This study aimed to investigate specific vegetation indices (VI) for three research sites: one grassland and two vineyards. It further examined the usability of grassland RS data to refine and enhance Normalized Difference Vegetation Index (NDVI) data in grass-covered inter-row vineyards.

One of the vineyards was located on silt loam textured soil (BCS), while the other was on a clay soil (GB), both situated on slopes with gradients ranging from 8 to 15%. A field monitoring system was established in 2020 and 2021 to collect NDVI, Photochemical Reflectance Index (PRI), and Photosynthetically Active Radiation (PAR) data at both upper and lower slope positions of the vineyards), which gathered the data at 10-minute intervals. In parallel with the in situ measurements, spectral data from the Sentinel-2 (S2) satellite were acquired to assess the correlation between field-based and satellite-derived NDVI values. For data comparison, the mid-day averages of the monitoring system at the time closest to the satellite passage days and the corresponding satellite values were used. Subsequently, various machine learning algorithms, including linear regression (LR), random forest (RF), and XGBoost, were used on 124 data to increase the accuracy of the measurement, with the generic 70% teaching and 30% testing ratio.

The determination of the optimal dataset and machine learning model for predicting grapevine health occurred in three stages: initially, only satellite-derived NDVI values of the vineyards were utilized; secondly, the day of year (DOY) variable was incorporated to capture phenological phase-specific variations; finally, NDVI data from the grassland site were integrated into the training process to adjust for the influence of grass-covered inter-rows.

Significant differences in vegetation indices were observed among the research sites, primarily correlating with soil chemical properties. A strong correlation was found between ground-truth and RS-derived NDVI measurements ($r = 0.68$), with the highest accuracy achieved by the RF model when training data included both DOY and grassland NDVI data ($r = 0.787$). The LR and RF models demonstrated robust predictive capabilities for grapevine vegetation indices when only basic information was available; however, all three models performed well when grassland data were incorporated into the training dataset.

ACKNOWLEDGEMENTS

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GT 08 - 448 - P

COPPER (CU), ZINC (ZN), AND MOLYBDENUM (MO) SIGNATURE IN ARARAT VALLEY SOIL (ARMENIA): A SOIL-TO PLANT PERSPECTIVE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 16. CONNECTING PEOPLE AND SOILS

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Agricultural soil properties are key factors affecting the micronutrient content in plants. Their uptake and accumulation in edible parts of plants largely depend on soil characteristics and human activities thus ensuring sustainable farming and food safety. This study focuses on the Ararat Valley - one of Armenia's most intensively farmed regions - aiming to assess the levels of Cu, Zn, and Mo in agricultural soils and their transfer to commonly consumed agricultural crops. A total of 65 plant samples and their corresponding soil samples were collected from various agricultural zones, including those near the industrial areas.

For detection of copper (Cu), zinc (Zn) and molybdenum (Mo) contents in plants and soil samples atomic absorption spectrometer and X-ray fluorescence spectrometer were used, respectively. In order to study the link between Cu, Zn, Mo, and the major and some other elements (Fe, Mn, Ca, K, Sr, Rb, Ti, Zr) hierarchical cluster analysis (HCA) was applied. This helped us better understand the complex relationships that influence micronutrient availability and uptake in crops, and unveil predominant geochemical factors conditioning the geochemical behavior of Cu, Zn, and Mo in soil and their uptake by crops.

The results indicated a notable variation in micronutrient uptake across different plant species. Leafy vegetables demonstrated a higher tendency to accumulate Cu and Zn. In contrast, melon and watermelon samples exhibited relatively higher levels of Mo. Hierarchical clustering revealed strong associations between Cu and Zn with Fe and Mn, suggesting their potential absorption by Fe/Mn oxyhydroxides. Mo displayed a strong link to Ca inferring the key role of Ca carbonates related to its mobility and uptake.

Calculated transfer factors (TFs) for Cu, Zn, and Mo from soil to plant were within typical agronomic ranges, with no evidence of excessive bioaccumulation. Dietary exposure assessments confirmed that estimated daily intake values for Cu, Zn, and Mo through fruit and vegetable consumption remain below EFSA's upper intake levels. However, comparatively higher element contents were observed near industrial zones, highlighting the need for further detailed studies in these areas. These findings contribute critical data for the development of evidence-based strategies aimed at improving soil fertility management, ensuring safe crop production, and guiding future monitoring programs in Armenia and other countries.

ACKNOWLEDGEMENTS

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GT 08 - 458 - P

ADVANCING PRECISION IRRIGATION IN OLIVE FARMING: FROM SENSOR DATA TO DIGITAL TWIN-BASED DECISION MAKING

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Olive cultivation is a key agricultural sector in Andalusia, Spain. Achieving optimal production and profitability hinges on effective crop management and market conditions. Water scarcity, worsened by recurrent droughts, significantly limits production. While various technologies aim to improve resource optimization, commercial-scale success remains limited to small experimental plots. From this need, the Sensolive Project (Sistema de riego deficitario en olivar con dendrómetros y gemelos digitales Inteligentes) was born, which aims to develop a fully autonomous irrigation decision-making system for olive groves, based on dendrometry and supported by complementary sensors.

The project will be carried out by the consortium composed of IG4 company, the University of Seville and the Institute of Natural Resources and Agrobiology (IRNAS-CSIC). The experimental work will take place at two commercial olive groves and an experimental farm (La Hampa, Coria del Río, Seville). Building upon the existing Globalsens platform, the project seeks to evolve from single-point sensor readings to a system that integrates digital twins for real-time estimation of water stress across entire orchards. The stations, located in strategic locations, are equipped with weather sensors, dendrometers, volumetric soil moisture sensors, and flowmeters. The project aims to improve water and nutrient management to optimize available water resources by developing an autonomous, highly configurable, reusable, and adaptable system capable of making irrigation strategy decisions. Additionally, the system is being optimized through the integration of dendrometers and digital twins at a commercial scale to reduce costs and maximize data quality, while also ensuring the dissemination of results and increasing the visibility of the proposed technology. In addition, it should be noted that water needs are closely related to nutrient management, as it can lead to more efficient systems in terms of water management. For this reason, compost and fertigation practices are applied in the trial with a special focus on nitrates (N-NO3) and potassium (K) levels in the soil. Monitoring these nutrients is essential, as nitrates are a key source of nitrogen necessary for plant growth and productivity, while K plays a critical role in water regulation, photosynthesis, and stress resistance. Real-time data from the sensors allows for precise adjustments in fertigation strategies, avoiding nutrient deficiencies or excesses that could negatively affect crop yield and environmental sustainability.

Laboratory soil analyses will be also conducted to compare the results with the data obtained from the field sensors and monitoring stations. This comparison will help validate the accuracy and reliability of the deployed technologies and tools. Demonstrating consistency between both sources of information is essential to confirm their effectiveness in optimizing resource management and reducing operational costs in olive groves and other crops on commercial farms.

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GT 08 - 460 - P

SORPTION AND DEGRADATION OF ALLELOCHEMICALS IN SOILS: RHIZOSPHERE EFFECTS OF HORDEUM VULGARE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 04. SOIL BIOLOGY

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In agroecosystems, plant-soil interactions constitute a fundamental component, serving as a primary regulator of nutrient and metabolite flow and availability, and influencing crop productivity and quality. In this context, the rhizosphere—the soil fraction directly influenced by plant roots—may play a decisive role in the fate and behavior of allelopathic compounds. This study evaluated differences in the availability and persistence of three allelochemicals (S-ABA, khellin, and S-pulegone) between rhizospheric and non-rhizospheric soil fractions, as well as potential changes in soil chemical composition and associated microbial communities. Rhizospheric soil was defined as the soil adjacent to the roots of Hordeum vulgare seedlings.

The results showed significant compositional and microbial population differences between rhizospheric and non-rhizospheric soil fractions and that the persistence of the allelochemicals varied with the soil proximity to the roots. In contrast, the sorption of the allelochemicals showed little difference between rhizospheric and non-rhizospheric soil. These findings suggest that the chemical and biological changes in soil properties induced by individual plant species may modulate the fate and activity of allelopathic compounds in natural and agricultural ecosystems.

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GT 08 - 483 - P

ENHANCING RESILIENCE OF RAINFED CERTIFIED OLIVE GROVES THROUGH THE USE OF BIOCHAR AND BENEFICIAL FUNGAL CONSORTIA

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Rainfed olive farming in the Mediterranean Basin is increasingly threatened by soil degradation, water scarcity, and dependence on synthetic inputs, primarily fertilizers. The RESIOLIVA Operational Group and the RES2SOIL project address these challenges through an agroecological approach aimed at enhancing the resilience and sustainability of certified olive groves under climate stress.

To this end, a field trial comprising 3,168 phytosanitary-certified olive trees of the Sikitita and Arbosana varieties—both mycorrhized and non-mycorrhized—was established in La Campana (Seville, Spain). The trial included six treatment combinations for each variety, involving the application or not of olive-mill-waste biochar and the inoculation or not of beneficial fungi from the Trichoderma genus, known for their biostimulant properties and ability to suppress soil-borne pathogens. The experiment evaluates the impact of these amendments on soil health and plant performance under rainfed conditions.

Comprehensive monitoring encompasses soil physicochemical properties (pH, electrical conductivity, resistance to penetration, moisture content, and water retention capacity), elemental and spectroscopic analyses (carbon and nitrogen content, thermal analysis, and FTIR spectroscopy), soil respiration rates, and plant physiological indicators such as chlorophyll content (SPAD index) and photosynthetic efficiency.

Preliminary results indicate that biochar application significantly increased soil organic carbon content in both Sikitita and Arbosana plots, with minimal effects on other soil properties. However, extreme rainfall in February 2025—exceeding 600 mm in a single month—resulted in unexpected flooding and unusually saturated soil conditions. This led to increased plant mortality and limited data collection during a critical phase. Nevertheless, the site remains under continuous monitoring to assess the long-term effects of organic amendments on olive tree survival and resilience under extreme climatic events. The findings are expected to support scalable, sustainable strategies for Mediterranean agroecosystems facing increasing aridity observed in recent decades.

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GT 08 - 485 - P

WATER BUDGET AND SOIL SOLUTION FLUXES FROM ICP FORESTS LEVEL II PLOTS. A CASE STUDY FROM THE MEDITERRANEAN SITES OF ITALY

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Atmospheric deposition is the primary source of reactive nitrogen in natural environments such as forest ecosystems. Forests have been exposed to increased atmospheric deposition of nitrogen in the 20th century. Such high depositions can induce N leaching from forest soils, therefore impacting water quality. Moreover, monitoring of negative impacts of air pollution on ecosystems is mandated by the National Emission Ceiling (NEC) EU directive (2016/2284). The present study aims to focus on the long-term monitoring of the processes and drivers implied in soil solution chemistry trends, analysing Italian sites belonging to the ICP-Forests Level II network.

In order to better constrain the fate of nitrogen in Italian forests, soil solution chemistry and temporal trends were monitored at selected plots. Soil water fluxes were estimated through a Soil-Vegetation-Atmosphere Transport model (SVAT), namely LWF-BROOK90. This model was recently implemented in R environment by Schmidt-Walter et al. (2020). Other estimates obtained by chloride tracing were compared. Finally, nitrogen outputs in draining soil water were estimated. The deterministic one-dimensional model was calibrated and validated by means of measured water content data obtained from TDR probes at three soil depths. We compared the results of different pedotransfer functions (PTFs), which led to different model output. Further investigations were led to better constrain the model: implementation of Rosetta PTF; application of field measured saturated hydraulic conductivity; phenological parameters, NDVI and LAI, derived from either remote sensing or throughfall chemistry; inverse parameter estimation employing HYDRUS 1-D model.

We found that high soil solution nitrate concentrations, above proposed threshold, in the sites located in or nearby the Po plain, led to N leaching from these forest sites. Even if complete retention of ammonium was observed, this likely greatly contributed to soil acidification through nitrification. This study presents a possible improved SVAT model parameterization for the Mediterranean sites, delineating future model developments.

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GT 08 - 498 - P

INFLUENCE OF ENVIRONMENTAL AND SOIL DYNAMICS ON IRON PLAQUE FORMATION IN HYDROPHYTES: IMPLICATIONS FOR CLIMATE CHANGE ADAPTATION

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Climate change represents one of the major ongoing challenges which deeply affect plant survival and soil functions. Variations in the mean sea level and saline water intrusion drive alterations in soil properties, such as electrical conductivity, redox potential or soil microbial activity, consequently to the cycle of several plant nutrients. In order to adapt to anoxia, hydrophytes have evolved a specialized tissue called aerenchyma to ensure constant aeration. Some of the O2 translocated to the roots, passively diffuses into the rhizosphere determining the oxidation of Fe2+ to Fe3+, which ultimately precipitate on the surface of roots as iron plaque. Plaques are important to regulate nutrient uptake and can possibly protect the root from contaminants uptake, functioning as a barrier against the entrance of toxic elements. Although many factors contributing to plaque formation have been extensively studied, aspects related to salinity and redox conditions remain poorly explored. They could alter plant ability to diffuse O2 and hence affect plaque formation.

The aim of this study was to assess the effect of environmental factors (i.e. salinity, flooding), soil properties (i.e. carbonate and sulphide contents, organic matter, pH, soil redox potential,), and plant traits (i.e. plant density, root exudation, root porosity) on the development of root iron plaques. Field work was carried out in the Marano Lagoon (NE Italy), along the Cormor and Stella River mouths. Common reed (Phragmites australis) was selected as a target plant. The interactions between water, soil and plant traits towards root plaque development were examined through Structured Equation Models (SEM) with the aim to highlight direct and indirect effect on plaque formation.

Results showed that plaque deposition is positively influenced by soil pH and negatively by redox potential, due to an increasing concentration of rhizospheric Fe2+ at high pH and low redox state. Additionally, plant density emerged as a significant factor, with higher densities correlating with increased plaque formation. This is likely due to the greater release of O2 from roots into the rhizosphere, which intensifies the oxidation processes responsible for plaque formation. Salinity and flooding did not affect plaque formation, probably a consequence of the high acclimation ability of the Common reed along the whole flood and salt gradient.

These results help to unveil new aspects of the complex interplay between environmental, plant and soil factors in determining plaque formation in wetland habitats, revealing the importance of the soil redox state over salinity, not only related to the reduction process of Fe3+ to Fe2+, but also to the soil microbial activity. This will potentially support the understanding on how wetland ecosystems respond to the ongoing challenges posed by climate change.



GT 08 - 534 - P

GENETIC PROGRESS IN BIOMASS PARTITIONING ENHANCES REPRODUCTIVE ALLOCATION IN WHEAT UNDER RESOURCE CONSTRAINTS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Over the past six decades, wheat breeding has progressively improved dry matter allocation to reproductive organs—a key adaptation for maintaining grain yield under phosphorus and water limitations. This study examines temporal changes in biomass partitioning strategies using two stage-specific indices: the Spike Partitioning Index (SPI) at anthesis and the Harvest Index (HI) at maturity. Thirty wheat cultivars representing four breeding periods (from pre-Green Revolution to modern releases) were evaluated under factorial combinations of phosphorus (3.4 and 30 mg P kg^{-1}) and irrigation (100% and 30%) on volcanic Andisols in southern Chile.

Results revealed significant genetic gains in early and final biomass partitioning. SPI increased by up to 85% in intermediate cultivars and remained elevated in modern genotypes, while HI displayed a steady annual increase of 0.26%, reaching a plateau near 0.58 in the most recent cultivars. Under baseline conditions (–W–P), modern lines such as Karnaval exhibited SPI values up to 3.3 times higher than Druchamp (1965), while elite cultivars like Rupanco and Maxwell reached HI values of 0.65 and 0.60, respectively.

Resource addition modulated SPI and HI differently across breeding periods. Phosphorus supply under water-limited conditions (–W+P) increased SPI by 19% in early post-Green Revolution cultivars and HI by over 10% in modern lines. Conversely, water addition without phosphorus (+W–P) reduced both indices in older cultivars, indicating limited capacity to utilize additional water under phosphorus deficiency. In contrast, modern genotypes maintained SPI and HI across all treatments, demonstrating greater phenotypic plasticity.

These differential responses across breeding periods indicate a shift from structural investment toward more efficient reproductive allocation. A moderate correlation between SPI and HI ($r = 0.42$, $P < 0.05$) in modern cultivars suggests improved synchronization in resource use, likely driven by indirect selection for sink strength. Overall, these findings highlight the importance of targeting both early and final biomass partitioning traits to improve yield stability under combined stress conditions. This insight supports ideotype-driven breeding and integrated nutrient–water management strategies, particularly in low-fertility and drought-prone environments.

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GT 08 - 537 - P

INTERACTIVE EFFECTS OF PHOSPHORUS FERTILIZATION AND IRRIGATION ON YIELD COMPONENTS OF WINTER WHEAT

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Phosphorus (P) and water are essential yet frequently limiting resources in wheat cultivation, especially under variable climatic conditions. This study evaluated the combined effects of P fertilization and water availability on grain yield and its components in three winter wheat cultivars (Fritz, Tukán, and Chevignon) grown on a volcanic Andisol over two seasons. Field trials included two P levels (10 and 30 mg P kg^{1}) and two irrigation regimes (rainfed and well-watered), with yield components assessed at maturity.

Phosphorus application promoted early vegetative development by increasing tiller formation, which resulted in higher spike density at harvest. Spike number per square meter increased by 70% under rainfed and 77% under irrigated conditions with P supply. Water addition enhanced this response, increasing stem density by 88% under irrigation with high P availability. Grain yield increased across all cultivars with P addition under rainfed conditions, with gains of 64%, 66%, and 90% for Fritz, Tukán, and Chevignon, respectively. Combined application of P and irrigation produced a synergistic effect, with yields reaching 14.12 t ha^{1} in Chevignon. This effect was more evident under water-limited conditions, suggesting that P fertilization improves yield performance under drought.

Yield component analysis showed differential cultivar responses, with Chevignon displaying the highest sensitivity to combined treatments. These results support the implementation of integrated nutrient and water management strategies tailored to cultivar-specific responses, contributing to yield stability under unpredictable rainfall in temperate volcanic soils.

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GT 08 - 598 - P

IMPACT OF SOIL HYDRATION AS AN ENVIRONMENTAL DRIVER ON SHIFTS IN THE FUNCTIONAL CHARACTERISTICS OF IMPATIENS PARVIFLORA

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 04. SOIL BIOLOGY

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The extensive riparian forest ecosystems bordering the Danube, vital habitats harbouring unique assemblages of flora and fauna, face increasing environmental pressures. Beyond direct anthropogenic impacts [1, 2], the escalating effects of climate change [3], manifesting as elevated mean temperatures and a concomitant reduction in soil moisture availability, pose a significant threat. These altered hydro-edaphic conditions are instigating shifts in interspecific competition within these plant communities [4], favouring the proliferation of invasive species [5], such as Impatiens parviflora, at the expense of native vegetation [6].

Our research has investigated the ecophysiological responses of naturalised populations of Impatiens parviflora within the floodplain forests near Bratislava, with a specific emphasis on the interplay between soil moisture regimes and key leaf functional traits. This invasive species exhibits notable phenotypic plasticity, demonstrating a capacity to tolerate water-limited conditions that often exceed the physiological tolerances of indigenous species [7, 8].

Analysis of the functional traits such as specific leaf area (SLA), leaf dry matter content (LDMC), and leaf water content (LWC) across a seasonal gradient of soil moisture revealed significant insights into the adaptive strategies of Impatiens parviflora. Higher SLA values observed during periods of adequate soil moisture in June indicated favourable growth conditions. While a subsequent drought period in July induced changes in these leaf traits, the magnitude of these shifts did not suggest a substantial decline in plant performance. Elevated LWC in June and increased LDMC in July further corroborate the species' remarkable ability to modulate its leaf physiology in response to fluctuating water availability within the soil matrix, facilitating its persistence and competitive dominance under increasingly dry conditions.

KEYWORDS

Floodplain forest, soil moisture, small balsam, leaf traits

ACKNOWLEDGEMENTS

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GT 08 - 656 - P

RUNOFF P DURING THE NON-GROWING SEASON IN TWO CONTRASTING CROPPING SYSTEMS IN THE FRASER VALLEY, BRITISH COLUMBIA, CANADA.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Direct assessment of P concentrations in runoff water from farm to estimate the potential risk of P pollution important. Its measurement will validate the relationship of P concentrations in runoff water and environmental soil P loss risk indicators such as the degree of P saturation (DPS), water soluble P (Pw), and P saturation index (PSI). Runoff water was collected during six major rainfall events from October to December, 2024 from two different fields in the Fraser Valley with contrasting cropping systems. Field one had a typical silage corn rotation, while field two had unfertilized grass with frequent cattle movement. Dissolved reactive P (DRP), particulate P (PP), and total P ranged from 0 - 1.26, 0 – 1.47, and 0.05 – 1.58 mg L-1, respectively in field one and from 0 – 5.17, 0 – 5.84, and 0 – 6.18 mg L-1, respectively in field two. Average DRP, PP, and total P was 0.14, 0.30, and 0.31 mg L-1, respectively in field one and 0.38, 0.59, and 0.66 mg L-1, respectively in field two. Decreasing trend in P concentrations in runoff water was observed with successive rainfall events in field one. While in field two, several peaks in P concentrations were observed. The contamination of runoff water by urine/manure from cattle potentially have caused this. Results on water sample analysis will be integrated with soil and hydrological data to develop a framework of a predictive model to estimate P losses that can provide an alternative to labor intensive direct assessment of P losses through runoff.

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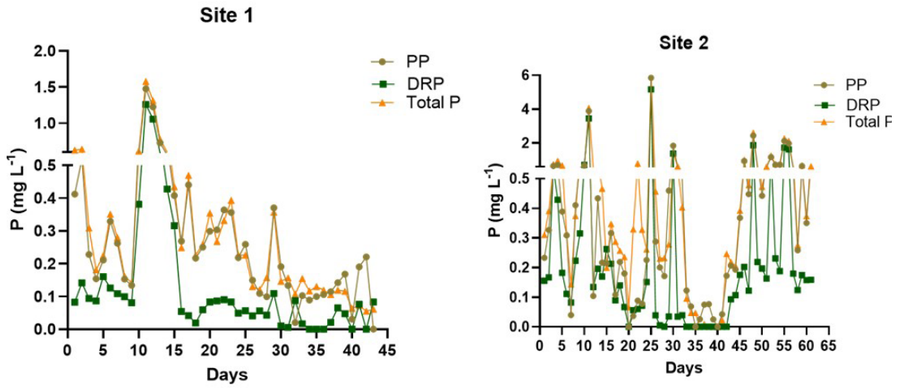


Figure: Runoff P in two contrasting cropping systems in the Fraser valley, British Columbia, Canada



GT 08 - 659 - P

SEASONAL CH4 EMISSION AND NITROGEN USE EFFICIENCY (NUE) OF RICE PLANTS UNDER NON-PUDDLING AND MID-SEASON DRAINAGE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Rice (Oryza sativa L.) is a stable food crop covering more than 40% (3.5 billion) of global population, however, leads to greenhouse gas (methane, CH4) emission. The objective of this study was to investigate the effect of agricultural practice such as non-puddling and mid-season drainage on seasonal CH4 emission and nitrogen use efficiency of rice plants. Four practices were employed as follows; 1) puddling + continuous flooding (P+CF, Control), 2) non-puddling + continuous flooding (NP+CF), 3) puddling + mid-season drainage (P+MD), and 4) non-puddling + mid-season drainage (NP+MD). Overall, mid-season drainage (MD) tended to reduce methane (CH4) emission, which was significant at vegetative stage (tillering). By contrast, non-puddling did not show the difference in CH4 emission. Nitrogen use efficiency (NUE) was also obviously affected by water management, which indicated that mid-season drainage contributed to greater NUE. Principal component analysis (PCA) showed that the association between CH4 emission and soil characteristics was markedly differed from growth stage, with great dependence of water management. Taken the results together, it is suggested that mid-season drainage could be a countermeasure to reduce CH4 emission during rice production without yield loss.

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GT 08 - 683 - P

NATURAL CONCENTRATIONS OF POTENTIALLY TOXIC ELEMENTS IN THE SOIL–RHIZOSPHERE–PLANT SYSTEM OF WILD PLANTS FROM THE ARGENTINE PUNA

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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In arid areas of the Argentinean Puna there is a high mobilisation of potentially toxic elements in the environment due to the high weathering conditions and that may affect the quality of the ecosystems. To determine the ability of plants to grow under high concentrations of potential toxic elements (PTE) and their effects on the biogeochemical processes, we analysed the soil-rhizosphere-plant system of Parastrephia lucida (Meyen) Cabrera, Distichlis humilis Phil., Festuca scirpifolia (J. Presl) Kunth and Parastrephia quadrangularis (Meyen) Cabrera species under natural conditions, which are of high abundance and representative of the area. They were sampled in the surroundings of the ‘Monumento Natural Laguna de los Pozuelos’ (Jujuy, N Argentina). Total concentrations of PTE such as Cd, Cr, Cu, Sr and Mn were determined in soil (S), rhizosphere (RH), root (R) and aerial part (AP) of each species. Mobility indices such as enrichment (EF = RH/S), bioconcentration (BF = AP/S) and translocation factors (TF = AP/R) were then calculated. The results showed high total concentrations of Mn (202-320 mg/kg), Sr (100-409 mg/kg) and Cd (18.3-31.9) and notable concentrations of Cr and Cu (< 66 mg/kg) in soil. In the rhizosphere, concentrations ranged from 129-492, 269-560, 0.5-7.1 mg/kg for Sr, Mn and Cd, respectively. In the case of Cr and Cu they were < 68 mg/kg, resulting slightly higher than those found in some soils.

In vegetation, concentrations of 9-22 mg/kg (Mn), 22-113 mg/kg (Sr) and 0.2-16 mg/kg (Cd) were found in the root, while concentrations of 18-345 mg/kg (Mn), 5-89 mg/kg (Sr) and 0-7 mg/kg (Cd) were found in the aerial part. Most significant results showed an EF of 7.4 for Cr, a BF of 4.1 and a TF of 5.1 for Cu in Parastrephia quadrangularis (Meyen) Cabrera which indicates a high capacity of these species to immobilize Cr into their rhizosphere as well as to mobilize Cu to their aerial part markedly. Distichlis humilis Phil. showed a TF of 15 and 5 for Mn and Cu, respectively, indicating these species pose a high capacity to mobilize Mn and Cu from the roots to the aerial parts. Therefore, these species can result adequate to be used as potential phytoremediators in this type of soils for several PTE.

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GT 08 - 778 - P

COMBINED USE OF BIOCHAR AND ALTERNATE IRRIGATION MAY ENHANCE RICE PRODUCTIVITY IN MEDITERRANEAN WATER-STRESSED REGIONS

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Rice (Oryza sativa L.) is typically grown under flooded conditions, which results in a high water footprint and soil degradation. This cultivation system is increasingly challenged by climate change. Therefore, implementing a crop management system that reduces water consumption and enhances soil conservation is essential. In this study, the effects of an alternate wetting and drying irrigation system combined with biochar application on agronomic and soil parameters were evaluated using the following treatments: traditional flooding (TF), traditional flooding with biochar application (TFB), moderate alternate wetting and drying irrigation (AI), moderate alternate wetting and drying irrigation with biochar application (AIB), severe alternate wetting and drying irrigation (SAI), and severe alternate wetting and drying irrigation with biochar application (SAIB). The results obtained in the third year of the study showed that the application of biochar increased soil TOC by a factor of 1.85, 2.25 and 2.58 in the TFB, AIB and SAIB treatments, compared to their counterparts without application. Regarding pH, treatments with intermittent irrigation (AI, SAI) showed higher values compared to those with continuous flooding (TF, TFB). Additionally, an increase toward near-neutral values was observed in treatments with biochar application (AIB, SAIB). Soil electrical conductivity dropped from 3.20 dS·m-1in the TF treatment to 1.09 in AI and 1.34 in SAI following the implementation of alternating irrigation. The combined effect of alternate irrigation with moderate water restriction and biochar application enhanced agronomic yield, with the highest production observed in the AIB treatment, reaching 12,236 kg·ha-1. In treatments subjected to severe water restrictions, biochar application increased yields to levels comparable to those achieved under traditional flooding conditions. In conditions of severe water stress, the incorporation of biochar led to an approximate 25% increase in yield, elevating productivity to levels comparable with those observed under moderate water restriction (AI, 11,672 kg·ha-1). In general, water productivity increased significantly with the severity of water restrictions, rising from 0.42 and 0.45 g l-1in TF and TFB, respectively, to 0.60 and 0.69 in AI and AIB and 0.66 and 0.95 in SAI and SAIB. These results also showed a significant increase in water productivity when biochar was applied in alternate irrigation treatments. Therefore, we can conclude that rice cultivation with alternate irrigation system and biochar application is an alternative management capable of improving production in Mediterranean water-stressed regions.

ACKNOWLEDGEMENTS

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GT 08 - 907 - P

COMPETITION BETWEEN COVER CROPS AND YOUNG GRAPEVINES UNDER CLIMATE CHANGE

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 09. SOIL HEALTH

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The implementation of cover crops in vineyards is a crucial strategy for protecting soil in agroecosystems and mitigating the effects associated with climate change. However, cover crops can compete with young grapevines prior to their termination. This study assessed the impact of different cover crops on soil properties and their interaction with the growth of first-year grapevines during the peak competition period (April–May). The experiment was conducted in mesocosms under semi-controlled conditions simulating various climate change scenarios.

Three main factors were evaluated: (i) grapevine variety (Airén or Tempranillo), (ii) type of cover crop (Medicago truncatula GAERTN, Trifolium subterraneum L., or a bare soil control), under two levels of water availability (medium or low), and two temperature scenarios (current temperature and +2 °C above current levels). The variables analyzed included ground cover percentage, soil penetration resistance, soil moisture and temperature, and total leaf number per vine.

Increased temperature had no direct effects on grapevine growth; however, reduced water availability was a key limiting factor for vine development. Medicago showed higher ground cover under medium water availability, although no significant differences were observed compared to Trifolium under low water conditions. Ground cover percentage was directly correlated with soil penetration resistance and inversely correlated with grapevine leaf number. This was attributed to lower surface soil moisture (0–12 cm) in the cover crop treatments compared to bare soil. Trifolium exerted less limiting effects than Medicago on leaf number under warming conditions. Ultimately, the early limitation in vegetative development of grapevines prior to cover crop termination led to reduced subsequent water requirements for grapevines, representing a further potential benefit under global warming scenarios.

KEYWORDS

Climate change, Cover crops, Young vineyards, Medicago sativa.

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GT 08 - 1020 - P

PERSISTENCE OF SOIL WATER REPELLENCY FOLLOWING PIG SLURRY APPLICATION

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil water repellency (SWR) limits the water infiltration into the soil matrix, altering the soil–plant–water dynamics and increasing surface runoff, preferential flow, and solute transport. In semiarid Mediterranean systems, where pig manure (or slurry) is used as fertilizer, concerns have arisen about SWR persistence, especially when slurry is not incorporated. This study evaluates SWR temporal dynamics following liquid manure application, focusing on the role of slurry characteristics, application method, and soil moisture cycles.

The experiment was conducted in NE Spain on a Typic Xerofluvent under rainfed cereal cropping. Pig slurry from fattening pigs or sows was applied at sowing (incorporated) and/or tillering (not buried). To evaluate the evolution of SWR, the Water Drop Penetration Time (WDPT) test was applied on the soil surface. Measurements started 24 h after application and lasted 1176 h (~49 d) thereafter. Soil moisture was simultaneously measured, and manure properties, including hydrophobic (OCho) and hydrophilic fractions of water- extractable organic matter, were analysed to link slurry chemistry with SWR dynamics.

SWR emerged after surface applications at tillering, reaching moderate levels (up to 242 s WDPT) in treatments with high water-extractable OCho, especially from fattening pig slurry (~3.5 kg m^{-3} OCho). These findings align with earlier studies that considered OCho fractions [1,2]. Soils were initially wettable, likely due to prior incorporation and tillage [3,4]. SWR occurred ~72 h after application, persisted until 840 h, and vanished by 1176 h, coinciding with soil rewetting. Prior slurry applications enhanced later SWR, suggesting cumulative hydrophobic effects. The highest repellency matched the driest soil conditions, confirming links between SWR and low moisture content [5,6].

In conclusion, pig slurry fertilisation can induce temporary SWR in semiarid conditions, which is governed by the chemical composition of the manure (especially the OCho), the soil moisture regime, and the history of application. While SWR lasted less than 49 d in this study, it may persist longer under dry conditions, repeated applications, or no-till systems. Immediate incorporation, moisture management, or using less hydrophobic slurries may help mitigate SWR risks.

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GT 08 - 1044 - P

SEMI-FIELD DEEP ROOT PHENOTYPING OF WHITE CLOVER WITH ISOTOPE ARRAYS AND INTERCROPPING

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Deep rooting is a desired trait for breeding more drought resilient crops, especially in areas with high precipitation outside of the growing season. Deep rooting is also a very impractical trait to phenotype, both due to the plasticity of roots and raw labor associated with creating and analyzing a deep soil matrix. This calls for high throughput phenotyping platforms with field-like conditions. There is furthermore the question of how to best phenotype crops for intercropping and if a pure stand set-up can give similar results.

In this 2-year phenotyping experiment, 8 genotypes of white clover (Trifolium repens) were phenotyped for deep rooting, deep water uptake, biomass yield and long-term stomatal closure (d13C with IRMS) both as monocrops and intercropped with ryegrass (Lolium perenne). To do this, we used a semi field root phenotyping platform, equipped with minirhizotrons and a sub-soil drip irrigation system. These would enable root imaging and root tracing respectively, by pumping isotope labelled water through the irrigation lines at 140-180cm depth.

At this very moment the second-year trial is close to termination and 2 years' worth of field data will soon be collected. For now, the first-year trial showed that the tracing system and the d13C array could show significant differences between genotypes, but there generally seemed to be no clear correlation between root traits and crop performance traits. Interestingly, the isotope enrichment showed the same pattern for both mono- and intercropped clover, strongly suggesting that the grass and clover were competing for water rather and that white clover can be phenotyped accurately without ryegrass.

However, one must wait until September, to see if the second-year season will repaint the image.

ACKNOWLEDGEMENTS

This project is supervised by Kristian Thorup-Kristensen and Dorte Bodin Dresbøll from the CROP section of the UCPH



GT 08 - 1090 - P

IMPACT OF SOWING TECHNIQUES, TILLAGE, AND COVER CROPS ON C AND N CYCLING IN A WINTER OILSEED RAPE CROPPING SYSTEM

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The carbon (C) cycle in agroecosystems is a key process influencing climate change, soil fertility, and agricultural sustainability. Plants play a central role in transferring atmospheric CO_2 into soil systems through photosynthesis, root exudates, and plant residues, contributing to the soil organic carbon (SOC) pool. Tillage intensity, sowing methods, and crop choice affect C inputs and their stabilization in soil. This study investigates the impact of different tillage and sowing methods on C and N distribution in winter oilseed rape (Brassica napus) and soil under temperate conditions.

Two factorial field experiment of different tillage and cover crop management was established in 2021 at the Lithuanian Research Centre for Agriculture and Forestry, Institute of Agriculture, in the long-term crop rotation fields located in Central Lithuania; the soil is classified as an Endocalcari– Epihypogleyic Cambisol, with a loam texture. A four-member crop rotation system was applied in the experiment: winter oilseed rape – pea (Pisum sativum) – winter wheat (Triticum aestivum L.) – spring wheat (Triticum aestivum L.). From 2024,the experiment involved three factors: Factor A – sowing methods: strip sowing without soil surface preparation (with 50 cm row spacing); sowing with pre-sowing soil cultivation; Factor B – tillage methods: conventional tillage (CT) (ploughing, 22–24 cm), reduced tillage (RT) (harrowing, 8–10 cm) and no-tillage (NT) (direct drilling); Factor C – cover crop application: with and without cover crop. The field experiment was arranged as a randomized complete block design with four replications. Crop maintenance was performed according to common agricultural practices, including pesticide application. In the 2024/2025 cropping season, winter oilseed rape plants and associated soil samples were collected and analysed.

The results showed that the highest accumulations of SOC, N and water-extractable C were found in soils where rape was sown using strip sowing. A similar tencency was observed for no-tillage practices and the use of cover crops, which also led to higher accumulation of these elements. Lower accumulations were likely caused by accelerated decomposition of organic matter in disturbed soils and reduced plant residue input in treatments without cover crops. The highest SOC concentrations were found in the 0–10 and 10–20 cm soil layers (2.15 and 2.09%, respectively), while the 20–30 cm layer contained nearly half as much.

In the plants, C accumulation was lower when cover crops were not used, whereas N concentrations were significantly higher under no-tillage compared to the other two tillage methods, and also when using strip sowing.

GT 08 - 1093 - P

HARNESSING WIRELESS TECH FOR REAL-TIME AGROFORESTRY MONITORING IN NORTH EAST ENGLAND, UK

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Agroforestry, the integration of trees with crops and/or livestock, offers a promising route to improve soil health, productivity, and climate resilience (1). Yet, monitoring soil-plant-water dynamics at scale remains a challenge. As part of the UK's 5G Innovation Regions Project, we deployed a real-time wireless sensor network at Cockle Park Farm, Northumberland, to monitor soil and microclimatic conditions across a 20-hectare silvoarable trial within a 307-hectare commercial farm (2). This trial is part of the Horizon Europe REFOREST network of agroforestry living labs (3).

The sensor network includes WET-150 (soil moisture, temperature, conductivity), PAR (photosynthetically active radiation), and SenseM30 (microclimate) sensors, installed across tree lines, crop alleys, and margins. Data are transmitted every 30 minutes via LoRaWAN to a 5G-enabled on-farm network, processed through the Daizy platform, and visualised using the EnableIOT dashboard (4). Soil nutrient levels are estimated using machine learning and validated quarterly with soil sampling.

Preliminary results from autumn 2024 show that tree lines significantly influence soil conditions. Moisture levels were higher and temperatures lower near trees, suggesting a buffering effect that reduces heat stress and conserves water. Rainfall events correlated with phosphate fluctuations, supporting the predictive value of nutrient models. These findings suggest agroforestry can create more stable, favourable conditions for crops.

We also explore agroforestry's impact on nutrient cycling and long-term soil health. In collaboration with the Organic Research Centre, stakeholder surveys will assess practical implications and inform future adoption. Outcomes will be discussed in the context of EU policy and agroforestry's role in sustainable land management and climate mitigation.

ACKNOWLEDGEMENTS

This research is part of the 5G Innovation Region (5GIR) programme, funded by DSIT, in collaboration with Sunderland City Council and the North East Combined Authority (NECA).

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3. REFOREST: https://agroreforest.eu/living-labs/
4. EnableIOT: https://enableiot.io/



INDEX

GT 08 - 1113 - P

SPONTANEOUS VEGETATION (“WEEDS”) MONITORING AS KEY SOIL BIO-INDICATORS IN MANGROVE RICE PRODUCTION AGROECOLOGIES IN GUINEA-BISSAU.

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Spontaneous vegetation (“weeds”) monitoring as key soil bio-indicators in Mangrove rice production agroecologies in Guinea-Bissau

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Abstract

The mangrove rice production (MRP) system is a cornerstone of food security, ecological stability, and cultural resilience in Guinea-Bissau’s coastal regions. Smallholder farmers manage these complex agroecologies under challenging soil–water interactions, influenced by tides, salinity, and nutrient fluxes. Recognizing the need for context-specific, low-cost, and ecologically sound indicators of soil fertility and degradation, this study explores the potential of spontaneous vegetation—commonly referred to as “weeds”—as bio-indicators of soil conditions within these systems. By integrating in-situ botanical assessment, soil isotopic analysis, and high-resolution remote sensing, we aimed to (1) monitor weed distribution and composition as indicators of soil fertility status, and (2) link plant functional traits and isotopic signals with underlying soil carbon (C) and nitrogen (N) dynamics in different agroecological zones of the MRP.

Methodology

Over two consecutive rice growing seasons (2022 and 2023), 297 composite topsoil samples (0–20 cm) were collected at critical phenological stages—post-tillage (sowing/transplantation) and flowering—across four key sites: Enchugal and Malafu (Oio region) and Cafine and Cafalé (Tombali region). A total of 155 spontaneous vegetation species were recorded in two recognized agroecologies within the rice fields, respectively the Tidal Mangrove – TM and the Associated Mangrove – AM (Figure 1). Weed monitoring included random sampling (2022) and georeferenced transect surveys (2023), coupled with drone-based (Phantom 4) multispectral image acquisition and Random Forest classification to map species abundance and spatial distribution.

Soil physicochemical parameters—pH, electrical conductivity, redox potential, particle size distribution, organic matter (OM), extractable phosphorus and potassium (Egner-Riehm method), and cation exchange capacity—were analyzed in the UGR Soil and Agricultural Chemistry Laboratory. Stable isotope analyses (δ13C and δ15N) of plant tissues, soils, and waterborne particulate organic matter (POM) were conducted at the CSIC-UGR Stable Isotope Biogeochemistry Lab using EA-IRMS technology.



Figure 1. Schematic cross-section of Catena and the distribution of the different agroecologies (TM, AM, AT and Nurseries).

Results

1. Weed Composition and Spatial Dynamics

A pronounced differentiation was observed between agroecological zones. In the associated mangrove (AM) areas (Oio), Echinochloa colona (Poaceae) dominated, forming dense mats during early growth phases. In the tidal mangrove (TM) plots (Tombali), Blutaparon vermiculare was the most dominant species, especially in saline, low-redox environments. Other indicator species included Sesuvium portulacastrum, a halophyte associated with high salinity and anaerobic conditions.

Remote sensing with the Phantom 4 drone achieved an overall classification accuracy of 88% (Figure 2), with species-level accuracy at 70.9%, notably in distinguishing Echinochloa spp., Blutaparon, and Sesuvium, despite misclassification challenges in high-biomass or shaded areas. Vegetation indices (NDVI, RedEdge NDVI) contributed to clear separation between functional plant types.

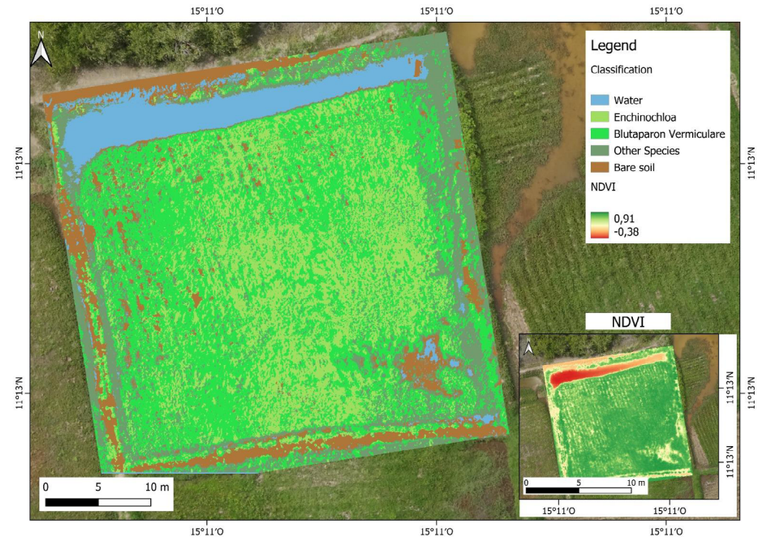


Figure 2. Plot 1 final classification for two main identified plant species; Ph-4 image taken the 24th July 2023.

2. Isotopic Insights and Organic Matter Sources

Isotopic analyses of soil and plant matter across the AM and TM agroecological zones revealed clear contrasts in the contributions of C_3 and C_4 vegetation to soil organic matter (OM). $\delta^{13}C$ values distinguished the two photosynthetic pathways, averaging –27.39‰ for C_3 species (e.g., Sesuvium portulacastrum, rice) and –13.71‰ for C_4 species (e.g., Echinochloa colona, Blutaparon vermiculare), confirming their unique biochemical signatures. These isotopic markers were traceable in soil profiles, particularly in the upper horizons, suggesting that organic inputs from C_4 plants decompose nearly twice as fast as those from C_3 plants—likely due to higher tissue turnover and lower lignin content.

Soil $\delta^{15}N$ values further indicated divergent nitrogen (N) cycling dynamics. In TM systems, $\delta^{15}N$ values were broader and enriched (mean: 6.5‰ in 2022 and 4‰ in 2023), suggesting denitrification under anaerobic, saline conditions. AM soils, in contrast, displayed a narrower $\delta^{15}N$ range with lower average values (2.59‰ in 2022, 1.2‰ in 2023), indicative of leaching and aerobic turnover. These patterns align with observed redox gradients and seasonal fluctuations, as TM zones often maintain waterlogged, reduced conditions that constrain aerobic decomposition and nitrogen retention.

$\delta^{13}C$ values in soils ranged from –18‰ to –30‰ in 2022 and –17‰ to –28‰ in 2023. For 2022, the mean $\delta^{13}C$ was more negative in AM soils (–25.3‰) than in TM soils (–19.6‰), consistent with a higher proportion of C_3-derived carbon in AM systems, likely from rice residues and C_3 halophytes. Carbon content was slightly higher in AM soils (1–2.7%) compared to TM soils (up to 2.5%), reflecting greater inputs of plant-derived organic material. Additionally, C/N ratios differed between agroecologies, with AM soils typically falling between 13–15 and TM soils between 8–12 in 2022. These findings suggest faster decomposition and potential nitrogen mineralization in TM zones, enhancing short-term nutrient availability but potentially limiting longer-term OM stability.

3. Soil Conditions and Vegetation Interactions

Soil physicochemical indicators, including pH, electrical conductivity (EC), cation exchange capacity (CEC), and redox potential, varied considerably across sites and seasons. AM soils were generally more acidic (mean pH 5.3), better aerated, and had lower EC, favoring the growth of fast-cycling C_4 Poaceae species. In contrast, TM soils were more saline (EC up to 8.3 dS/m) and displayed consistently low redox potential, creating challenging conditions for traditional rice cultivation but supporting salt-tolerant halophytes like Sesuvium and Blutaparon.



Green biomass coverage, which was used as a proxy for vegetative activity, showed a strong positive correlation with soil organic matter (R^2 = 0.71), particularly during early phenological stages. This indicates that high weed biomass—regardless of crop type—can reflect underlying soil fertility status and active nutrient cycling. In this sense, spontaneous vegetation becomes a functional indicator of soil health, especially in systems lacking access to regular soil testing.

4. Weed Isotopic Signals and Functional Traits

Vegetation isotopic analysis confirmed a clear separation between C_3 and C_4 photosynthetic groups, with $\delta^{13}C$ values forming two distinct clusters. C_3 species (e.g., Sesuvium, rice) had $\delta^{13}C$ values averaging –29.5‰, while C_4 species (e.g., Echinochloa, Blutaparon) averaged –12.6‰. The $\delta^{15}N$ range spanned from –8.5‰ to +13.0‰ across all weed samples, reflecting both species-specific uptake dynamics and soil nitrogen availability (Figure 3). C_3 plants showed slightly higher mean $\delta^{15}N$ (3.52‰) than C_4 species (3.05‰), though overlaps suggest shared sources or simi lar microbial processing pathways.

C/N ratios further differentiated these groups. C_4 specie s had higher average C/N ratios (38.7) compared to C_3 plants (27.4), indicating a lower nitrogen content and potentially more recalcitrant biomass. This was supported by total N content: 2.20% in C_3 plants versus 1.53% in C_4 species. Meanwhile, carbon content was relatively stable between groups (~36–38%), though with greater variability in C_3 plants (Figure 3). These differences underscore contrasting ecological roles: C_3 plants may contribute more labile nitrogen-rich organic matter, whereas C_4 species offer high-biomass inputs but slower decomposition, affecting OM turnover and nutrient availability differently.

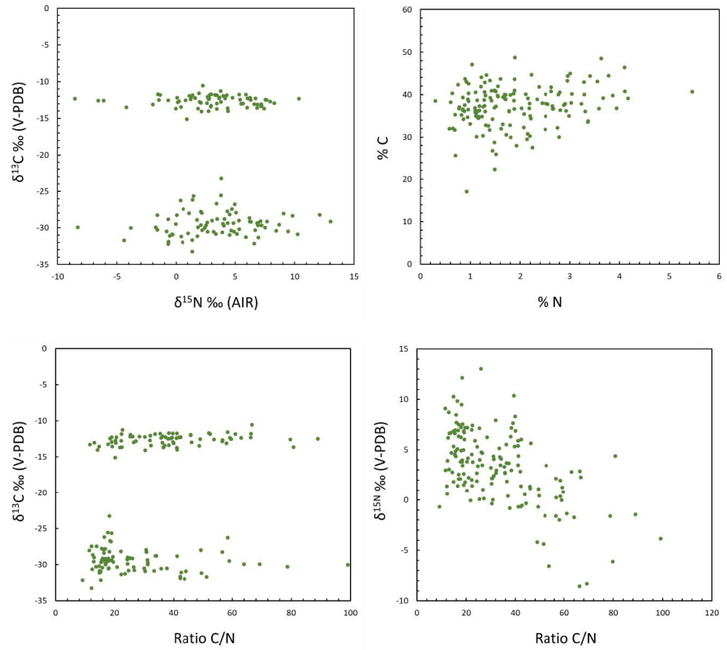


Figure 3. (a) Isotopic δ13C vs δ15N; (b) C to N in %; (c) isotopic δ13C and C/N ration and (d); isotopic δ15N and C/N ration for all sampled species (n=154) from sampling 2022 and transect campaign July 2023.

Species-specific isotopic profiles reinforced these trends. Echinochloa colona and Blutaparon vermiculare had $\delta^{13}C$ values between –13‰ and –15‰, characteristic of C_4 metabolism. In contrast, Sesuvium portulacastrum—a facultative halophyte with C_3 photosynthetic traits—showed $\delta^{13}C$ values as negative as –31‰, suggesting minimal water stress and efficient carbon fixation. Rice, used as a reference crop, showed similar C_3 signatures ($\delta^{13}C$: –29‰ to –31‰; $\delta^{15}N$: ~2‰ to 11‰), overlapping with Sesuvium.

Dominant C_3 isotopic signatures in soil OM across both agroecologies indicate that post-harvest residues (rice straw, roots) and persistent halophytes contribute significantly to the SOM pool. This trend suggests anthropogenic influence via crop introduction and field management that favors C_3 biomass inputs.

5. Soil–Weed–Water Interactions

Stable isotope comparisons between soil, weed, and water samples revealed tightly linked C and N dynamics shaped by hydrological conditions and plant physiology. Soils fell predominantly within the C_3 range, reinforcing the role of rice and Sesuvium in shaping SOM composition. Water $\delta^{13}C$ values also aligned closely with C_3-derived organic inputs, pointing to significant contributions from terrestrial vegetation and possibly aquatic primary production (e.g., algae).

Seasonal variation in water samples was evident. Wet season $\delta^{13}C$ values averaged –27‰ (2022), while dry season samples were less negative (mean: –23‰) (Figure 4), indicating changing organic matter sources and potential shifts in microbial decomposition or dilution from tidal influx. Despite the abundance of C_4 species in AM fields, their influence on aquatic and soil $\delta^{13}C$ values was limited, likely due to their slower decomposition or lower incorporation into the SOM pool.

This pattern supports findings by Wynn & Bird (2007), who demonstrated that although C_4 plants may dominate biomass production, their isotopic influence in soil and water systems is often buffered by the slower turnover of their lignified tissues. Consequently, C_3 plants—despite lower biomass—play a disproportionately important role in shaping biogeochemical signatures due to their faster decomposition and integration into nutrient cycles.

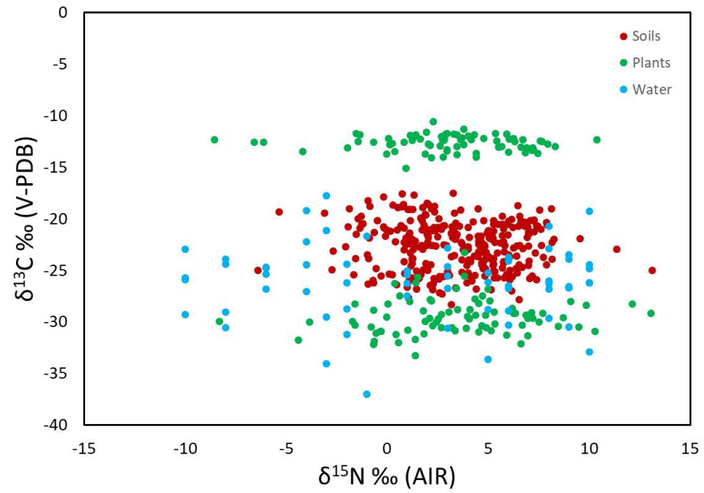


Figure 4. Nitrogen δ15N and Carbon δ13C isotopic signatures in soils (red), plants (green), and POM- (blue), including overall samples for 2022 and 2023. Note: The $\delta^{15}N$ values for water samples are approximated for visualization purposes, as all measured values were recorded as 0‰. This adjustment was made to allow for consistent and comparative representation across all sample types.

Discussion

This multi-isotopic analysis across soil, water, and vegetation compartments underscores the value of spontaneous vegetation as both an indicator and driver of ecological processes in mangrove rice agroecosystems. The widespread presence of C_4 weeds in AM systems, especially Echinochloa, reflects nutrient-rich zones with fast turnover and high input–output flows. Meanwhile, TM fields—more constrained by salinity and waterlogging—are increasingly dominated by halophytes such as Sesuvium, signaling ecological transitions that may hinder traditional rice cultivation.

Notably, isotopic signals reveal not just source attribution (C_3 vs. C_4), bu t also functional dynamics such as decomposition rates, nitrogen mineralization, and salinity effects on plant uptake. Drone-based mapping of weed biomass and spectral signatures enhances the scalability of these insights, offering a spatially explicit lens on soil health indicators.

Integrating isotopic data with remote sensing and field surveys allows for the identification of “bio-indicative species” whose presence, abundance, and isotopic traits can inform site-specific management decisions. In systems such as Guinea-Bissau’s smallholder rice landscapes—where regular soil testing is rare—such integrative approaches provide a cost-effective and scalable toolkit for agroecological assessment.

Conclusion

Spontaneous vegetation in mangrove rice agroecologies—frequently regarded as undesirable weeds—emerges as a critical source of ecological information. Their isotopic signatures offer insights into organic matter turnover, nutrient cycling, and hydrological interactions, providing early warnings of degradation or fertility constraints. This study illustrates how C_3 and C_4 species contribute differently to SOM dynamics, with rice and C_3 halophytes driving most carbon inputs, and C_4 weeds reflecting rapid nutrient cycling in fertile zones.

The combination of isotopic analysis, botanical monitoring, and drone imaging presents a robust, multiscale diagnostic framework for soil health assessment. It bridges biophysical data with practical land management and offers new pathways for participatory extension services. Specifically, farmer training programs and local monitoring networks should incorporate weed-based indicators into soil fertility diagnostics, supported by accessible tools for interpreting drone and isotopic data.

Ultimately, in the face of increasing salinization and climate variability, recognizing weeds as ecological allies—not merely pests—opens new frontiers for building resilience and sustainability in West African coastal rice systems.

Spontaneous vegetation (weeds) monitoring as key soil bio-indicators in MSR_ M.Merkohasanaj_3.pdf



GT 08 - 1123 - P

EFFECTS OF INDUCED DRYING CYCLES ON THE ESTIMATION OF SOIL HYDRAULIC PROPERTIES BY SEM AND INVERSE MODELLING

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 05. SOIL HYDROLOGY & EROSION

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The soil hydraulic properties (SHP), namely soil water retention and soil hydraulic conductivity, is crucial for accurately modelling water dynamics and solute transport within the soil profile. The simplified evaporation method (SEM) (Peters & Durner, 2008) is an efficient approach to derive SHP by analysing evaporation-induced changes in a single soil column or soil core. Despite its growing use, the SEM's robustness under conditions of artificially imposed water stress has not been comprehensively examined across a full range of moisture contents under regulated deficit irrigation strategies. In areas under Mediterranean climate influence such as in Catalonia, several crops like almond and vineyards are cultivated under conditions of water stress due to low hydric availability to watering agricultural plants at its maximum demand. This study evaluates the soil hydraulic properties from near-saturation to residual water content for two different soils cultivated with almond and vineyard subjected to controlled drying cycles. Undisturbed soil samples were collected at multiple depths to capture vertical SHP variability influencing water dynamics critical for irrigation management in these perennial cropping systems. The measurements of full water potential range were done combining the HYPROP and the WP4C potentiometer devices (METER Group Inc., Pullman, USA). The SHP was estimated from HYPROP+WP4C measurements after adjustment to the van Genuchten-Mualem model, vG (van Genuchten, 1980). Data on soil mass loss and corresponding pressure heads were analysed through inverse modelling using the vG model implemented in HYDRUS-1D software (Šimůnek et al., 2016) to obtain water retention and hydraulic conductivity functions. Results indicate significant differences in hydraulic behaviour between almond and vineyard soils, with vineyard soils exhibiting greater water retention and hydraulic conductivity under dry conditions, potentially attributed to root system architecture and soil retention capacity. Induced water stress treatments revealed nonlinear responses in hydraulic conductivity, underscoring the necessity of precise soil moisture characterization to enhance irrigation scheduling. These findings contribute to improved understanding of soil-plant-water relations in Mediterranean perennial crops, providing a foundation for optimizing water use efficiency and sustaining agricultural productivity under increasing drought pressure.

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GT 08 - 1138 - P

Evaluation of the Agricultural Application Potential of Superabsorbent Polymer (SAP)

GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 02. SOIL PHYSICAL CHEMISTRY

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Introduction:

Recently, the frequency of extreme weather events, particularly droughts, has increased due to global warming. Superabsorbent polymers (SAP) are synthetic polymer materials capable of absorbing large amounts of water. By utilizing the characteristics of SAP, it is believed that soil moisture retention can be improved, thereby enhancing soil quality and increasing crop productivity. Therefore, this study aims to evaluate the agricultural application of SAP by applying it to soil and analyzing moisture retention within the soil, biodegradability, crop productivity, and changes of soil physico chemical properties

Material and Method:

Mixed SAP with soil and maintained 65% of the field capacity at 25°C to analyze the CO2 emissions using Gas Chromatography. Also mixed SAP with soil and periodically dry the soil to measure its weight. To investigate the effects of SAP on crop growth and changes in the physicochemical properties of soil, lettuce (Lactuca sativa L.) was cultivated by treating the soil with 0.01, 0.05, 0.1, 0.5, and 1% SAP based on soil weight. The fresh, dry weight, and nutrient content (N, P, K, Mg, Ca) of the lettuce were analyzed. The soil was classified into two types (sandy loam and clay loam) based on its texture.

To examine the changes in the physicochemical properties of the soil after harvesting, analysed pH, EC, T-N, T-C, Available P, CEC, Ex. cations, field capacity, porosity, and water-stable aggregates.

Results:

Both CO2 emisson and weighting methods showed similar decomposition rates, with a decomposition rate of 15.5 to 22.9% in the soil. When SAP was applied at 3% based on soil weight, it was found to maintain 20.2 to 36.9% more moisture compared to the control treatment. This capability was retained even after undergoing more than three drying cycles. In clay loam, the best growth was observed at the 0.05% treatment level, while in sandy loam, it was at the 0.1% treatment level. When SAP was applied at levels of 0.5% and 1% or more, there was growth inhibition we can see. CEC was highest in the 0.05% and 0.1% treatment levels, where crop growth was the best. Field capacity, porosity, and water-stable aggregates tended to increase with higher SAP treatment levels.

Conclusion:

This study confirmed that SAP has positive effects on crop yield and soil physicochemical properties.

However, since these results are based on laboratory experiments, further field studies are necessary to reaffirm its agricultural applicability.

KEYWORDS:

Superabsorbent polymer, soil moisture retention, crop productivity

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GT 09. SOIL HEALTH

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 09 - 18 - O

RAPID INCREASE IN SOIL ORGANIC CARBON AND STRUCTURAL STABILITY IN A SANDY LOAM SOIL FOLLOWING CONVERSION FROM LONG-TERM ARABLE TO SEMI-NATURAL GRASSLAND IRRESPECTIVE OF INITIAL SOIL CONDITIONS

GT 09. SOIL HEALTH / GT 02. SOIL PHYSICAL CHEMISTRY

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Converting arable land to semi-natural grassland has the potential to restore soil structural stability (SSS) and increase soil organic carbon (SOC) storage. However, the effect of the initial soil C level and conditions on the changes following introduction of grassland is poorly understood. We quantified changes in SSS and SOC in topsoil from the Askov straw disposal and cover cropping experiment initiated in 1981 in Denmark before and after its conversion to semi-natural grassland in 2020. Due to different straw input and cover crop use in the arable phase, the grass was established on soils with different initial conditions (11.9–17.9 g C kg− 1 oven-dry soil). Soils sampled in 2019 and 2021 from plots subjected to different treatments in the arable phase were analyzed for clay dispersibility measured on two macro-aggregate sizes (ClayDis 1–2 mm and ClayDis 8–16 mm), wet stability of aggregates (WSA) and SOC. Irrespective of initial soil conditions, introduction of semi-natural grassland resulted in a rapid increase in SOC, a decline in ClayDis 1–2 mm and no change in WSA. The relative change in ClayDis 1–2 mm was larger than the change in SOC, and the slope for the relationship between SOC and ClayDis 1–2 mm decreased after conversion to grassland. Based on these observations, we suggest that the additional driver in play was aggregate-binding and -bonding agents being persistent due to the absence of tillage following the conversion to grassland. Notably, changes in SOC and SSS were similar regardless of initial soil conditions, which may be related to a similar productivity in the semi-natural grassland and soil C saturation.

ACKNOWLEDGEMENTS

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Station for their careful maintenance of the straw experiment both

before and after conversion to semi-natural grassland. The study was

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Soil property	SOC 2019	SOC 2021	ClayDis 1–2 mm 2019	ClayDis 1–2 mm 2021	WSA 2019	WSA 2021
Straw rate (SR)	***	*	**	*	ns	*
Cover crop (CC)	**	ns	ns	ns	ns	ns
SR × CC	ns	ns	ns	ns	ns	ns
Straw rate (Mg/ha)	**(g kg^{-1} minerals)**		**(g kg^{-1} minerals)**		**(kg kg^{-1})**	
0	13.6^{a}	14.7^{a}	4.66^{b}	3.74^{b}	0.84^{a}	0.84^{a}
4	15.0^{ab}	15.6^{ab}	3.84^{ab}	3.21^{ab}	0.86^{a}	0.86^{ab}
8	16.0^{bc}	16.6^{ab}	3.66^{ab}	3.26^{ab}	0.92^{a}	0.87^{ab}
12	17.0^{c}	18.2^{b}	3.29^{a}	2.80^{a}	0.86^{a}	0.91^{b}
Cover crop	**(g kg^{-1} minerals)**		**(g kg^{-1} minerals)**		**(kg kg^{-1})**	
Without ryegrass	14.8^{a}	15.7^{a}	4.07^{a}	3.37^{a}	0.86^{a}	0.86^{a}
With ryegrass	16.0^{b}	16.8^{a}	3.66^{a}	3.13^{a}	0.88^{a}	0.88^{a}

*Table 1 Analyses of variance (ANOVA) for soil organic carbon (SOC), clay dispersibility of 1–2 mm rewetted aggregates (ClayDis 1–2 mm) and wet stability of 1–2 mm aggregates (WSA) for the four straw rates (SR: 0, 4, 8, 12 Mg ha- 1) and two cover crop treatments (CC: without and with a ryegrass cover crop) for 2019 and 2021. Within columns, letters denote statistical significance at P < 0.05. *, **, *** and ns mean significant at the 0.05, 0.01, 0.001 and not significant, respectively. For ClayDis 1–2 mm measured in 2019 two outliers were omitted from the analysis*



GT 09 - 21 - O

SOIL MONITORING: STANDARDISED PROTOCOLS FOR THE ASSESSMENT OF BIODIVERSITY AND ECOSYSTEM SERVICES [SOIL HEALTH AND RE-EVALUATION; SHARE PROTOCOLS]

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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1. Healthy soils are essential for food production, carbon and water storage and buffering climatic change. As the majority of soils are currently considered unhealthy, evaluation of restoration and management practices requires the regular and systematic monitoring of the physical, chemical, and biological conditions of soil and their overall status. To implement this practice, it is essential to have standardized methods to measure a comprehensive set of physical, chemical and biological indicators, alongside conventional soil descriptions. Here, we present a harmonised protocol for the planning of systematic soil monitoring across continental scales at a single timepoint, from site selection, sampling to data generation. This approach will allow for data integration and produce informative outputs for stakeholders, researchers, landowners and policymakers.
2. Our proposed sampling and processing techniques will minimise methodological and sampling bias by monitoring soils with particular focus on soil faunal and microbial biodiversity. These are evaluated against existing methodologies, data resources, and monitoring efforts.
3. The proposed methodology is based on national and European soil research approaches and has been successfully applied in the HORIZON 2020 Soil Missions funded project “Soil Biodiversity into Ecosystem Services” (SOB4ES) that is developing cost-effective biotic and abiotic indicators of soil conditions across land-use types, intensities and pedoclimatic zones covering 12 European nations.
4. Standardised soil monitoring protocols that combine a comprehensive set of soil parameters with total soil biodiversity across the trophic web are key to gathering datasets comparable across a range of ecosystem types. This will enable robust evaluation of soil condition in respect to management practices, environmental policy, and responses to natural and human-induced environmental change.

GT 09 - 33 - O

REUSING EXCAVATED SOILS AND CONSTRUCTION MATERIALS TO RESTORE SOIL FUNCTIONALITY AND ENHANCE SUSTAINABILITY: A CROSS-DISCIPLINARY EXPERIMENTAL APPROACH AT CHALLENGER

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The increasing anthropogenic pressure on soils necessitates a paradigm shift in construction practices to ensure the preservation and regeneration of soil resources. Conventional construction methods contribute to soil artificialization and compaction, leading to irreversible degradation that impairs key ecological functions, including water regulation, carbon sequestration, and biodiversity support. Addressing these challenges requires innovative, science-driven approaches to reclaim and refunctionalize degraded soils.

To explore practical solutions, an experimental demonstrator has been established at Challenger, the headquarters of Bouygues, to investigate the potential reuse of excavated soils and construction materials for the restoration of soil functionality. The project integrates four key applications: (i) Green spaces : designed to enhance water infiltration, soil structure, and biodiversity regeneration ; (ii) Ecological rehabilitation : focusing on the reconstruction of biologically active soils in degraded environments ; (iii) Urban agriculture, evaluating the feasibility of food production on reconstituted substrates ; and (iv) Rooftop and slab gardens : addressing the challenges of greening artificial and impervious surfaces.

This demonstrator follows a rigorous scientific approach by evaluating various soil health indicators. The analysis includes physico-chemical parameters, such as soil structure, organic matter content, pH, and cation exchange capacity (CEC), as well as biological criteria, including microbial activity, biodiversity, plant biomass, and species monitoring. The ecosystemic dimension is also considered, particularly water retention and carbon storage. Finally, a sanitary assessment is conducted through heavy metal analysis and ecotoxicological monitoring to ensure the compatibility of the soils with their intended future use.

Beyond its experimental scope, this initiative functions as a catalyst for industry-wide transformation by fostering an evidence-based, participatory approach. This model actively engages construction professionals, soil scientists, and land managers in the co-development of scalable, sustainable soil management solutions. The objective is to drive systemic change in construction practices by demonstrating the tangible ecological and economic benefits of soil circularity, while ensuring widespread adoption through capacity-building initiatives, professional training programs, and applied case studies.

This research contributes to the broader discourse on circular economy strategies in soil sciences and underscores the critical role of transdisciplinary collaboration in mitigating soil degradation and enhancing urban resilience.

ACKNOWLEDGEMENTS

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GT 09 - 62 - O

SOIL MICROBIAL BIOMASS AND ORGANIC CARBON IN AGRICULTURAL FIELDS OF THE EBRO VALLEY (NE SPAIN) UNDER DIFFERENT MANAGEMENT PRACTICES

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Inadequate agricultural management is one of the main causes of soil degradation. Soil management, use of agrochemicals and fertilisers affect the soil environment and can cause a progressive loss of soil quality. Biological and biochemical properties of the soil respond rapidly to environmental disturbances and serve as indicators of soil quality. However, these properties might be related to the soil organic carbon content, which may mask the impact of agricultural management on them. In this work, the relationships between soil organic carbon, microbial biomass and basal respiration were assessed in agricultural fields subjected to different management practices (tillage, no tillage, green covers) in Aragón. Paired plots, either tilled or managed under conservation agricultural practices including cover crops were selected in seven municipalities of Aragón: Bolea, Castejón del Puente, Épila, Muel, Pina de Ebro, Sádaba, and San Martín del Río. Crops were different in each location, including cereals, olive groves, almond and fruit orchards, and vineyards. Each plot was divided into 4 zones from which a composite sample (composed of 4 to 6 soil cores) was collected, amounting to a total of 62 samples. When gathering all data, Pearson's correlation coefficients (r) between soil organic carbon, microbial biomass and basal respiration, despite being significant, ranged between 0.36 to 0.53. When calculated on samples from field crops, they remained within the former range. However, when calculated on samples from perennial orchards, they substantially increased, ranging from 0.74 to 0.81. Clear differences in the slopes of the regression lines were detected between samples from field crops and perennial orchards (Figure 1). These results suggest that, despite the significant correlations observed, additional factors might be considered when evaluating the response of soil biochemical properties to agricultural management.

ACKNOWLEDGEMENTS

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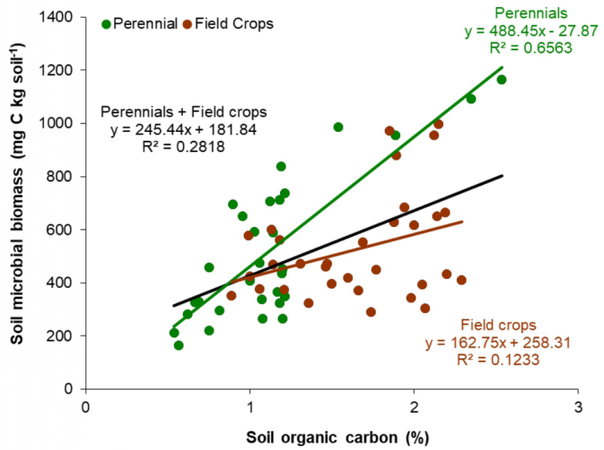


Figure 1. Relationships between soil organic carbon and microbial biomass in samples collected from field crops and perennial orchards located in Aragón (NE Spain) and subjected to different agricultural practices.

GT 09 - 76 - O

SOIL BIO-MONITORING IN POLAR ECOSYSTEMS: FINDINGS FROM LIVINGSTON ISLAND, ANTARCTICA

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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This study presents preliminary results on soil parameters and microbial biodiversity in the polar ecosystems surrounding the Bulgarian Antarctic Base "St. Kliment Ohridski". Soil monitoring in this region aims to evaluate key soil characteristics and their influence on the structure, composition, and ecological role of fungal and bacterial communities, which are essential for nutrient cycling and ecosystem stability. Soil pH, organic matter content, texture, mineral composition, and moisture were analyzed in experimental monitoring plots established in 2020. Antarctic soils on Livingston Island were found to be slightly acidic to neutral (pH 5.2–7.1), depending on factors such as mineral weathering, biological activity, and ornithogenic sites. Carbon content varied significantly, with ornithogenic soils exhibiting higher levels due to accumulated guano, which supports distinct microbial communities. Organic matter was a key determinant of fungal diversity and enzymatic activity. Soil moisture levels ranged from 5% to 22%, influenced by

nowmelt and seasonal variations. Elevated nitrogen content was detected in ornithogenic soils, associated with microbial nitrogen fixation and decomposition processes. Carbon cycling was closely linked to fungal activity, particularly in organic-rich soils. DNA sequencing revealed a complex microbial ecosystem dominated by fungi and bacteria in the soil samples. Microbial activity was highest in moderately moist soils, while extreme dryness in some areas limited biological processes. The fungal community consisted primarily of Ascomycota (74%) and Basidiomycota (10%), with minor contributions from Mortierellomycota and other phyla. Bacterial communities were mainly composed of phyla Actinobacteria, Proteobacteria, and Firmicutes, which play crucial roles in nutrient cycling

and organic matter decomposition. Microbial diversity was strongly influenced by soil parameters, particularly organic matter, moisture, and nutrient content. Fungal and bacterial biodiversity in Antarctic soils contributes significantly to organic matter decomposition, nutrient recycling, and symbiotic interactions with other microorganisms. The identification of psychrophilic fungi highlights their adaptations to extreme cold environments and their role in soil formation and stabilization. These findings emphasize the significance of Antarctic soil ecosystems as reservoirs of unique biodiversity, adapted to one of the most extreme environments on Earth. Soil parameters play a fundamental role in shaping microbial communities, influencing their diversity and functional roles in nutrient cycling and ecological stability. Continuous monitoring of these ecosystems provides critical insights into climate change impacts and potential biotechnological applications.

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GT 09 - 140 - O

SOIL HEALTH INDICATORS FOR CROPPING SYSTEMS IN MANITOBA, CANADA

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil health is the collective functioning of chemical, physical, and biological properties in soil. Soil management affects soil health and agronomic outcomes, but the magnitude and direction of these complex interactions needs further elucidation to increase relevance for farmers. We conducted two experiments to understand the interrelations of tillage systems and crop sequences on soil health properties and agronomy. Tillage systems at Portage la Prairie, MB, Canada were cultivation, deep tillage, raised beds, and vertical tillage. Soybean (Glycine max (L.) Merr), corn (Zea mays L.), and canola (Brassica napus L.) were grown in 2020, 2021, and 2022. Twenty five crop sequences were setup at Morden, MB, Canada over a two-year period. The crop sequences included alfalfa (Medicago sativa), canola, corn, soybean, and wheat (Triticum aestivum L.) grown north to south in 2021 and then east to west in 2022 creating 25 crop sequence combinations. Crop yield, seed protein content, and seed oil content were measured each year. Soil samples were analyzed for commercially available soil health indicators including nitrate-N, ammonium-N, total N, ACE protein, water extractable organic N, water extractable total N, water extractable ammonium N, soil organic matter, soil organic carbon, calcium carbonate equivalent, CO2 burst, permanganate oxidizable carbon, water extractable organic C, pH, salts, Olsen P, K, S, sand, silt, and clay. Soil health indicators and their interactions with agronomic outcomes including crop yield, seed protein content, and seed oil content differed between crops and growing seasons. Soil health indicators related to soybean agronomic properties more often than for corn and canola in the tillage trial. Soil health indicators were more likely to relate to agronomic outcomes in a dry year compared to a wet year in the crop sequence trial. In other words, soil health indicators were not consistent predictors of agronomic outcomes relevant to farmers. This suggests that the utility of soil health indicators may be crop and growing condition specific. Further research is needed to understand the mechanisms underpinning the ability of soil health indicators to predict agronomic outcomes and to benchmark soil health indicator values with time.

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GT 09 - 157 - O

IMPROVING SOIL HEALTH THROUGH NATURE-BASED SOLUTIONS: THE EFFECTS OF OLIVE-POMACE-BASED COMPOSTS

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Loss of soil organic matter (SOM) is a major issue in Mediterranean regions, especially in NE Portugal, where about 70% of soils are classified as Leptosols. On the other hand, olive groves dominate the region's farmland, and the olive oil industry generates large quantities of by-products. Two-phase olive pomace (OP) has a high organic load and is phytotoxic due to its high phenolic content. Composting OP with other agri-residues offers a nature-based solution that addresses untreated OP disposal challenges while recycling nutrients and supporting the circular economy.

This study evaluates the effects of olive pomace-based composts (OPC) on soil physical and chemical properties. OPC was produced by composting OP with sheep manure and almond shells. In a pot trial, 3 OPCs produced with different %OP (OPC44, OPC31 and OPC25) and a commercial organic corrective (HMC) were incorporated in the 0-5cm layer of an eutric Leptosol (2.1% OM) at three doses (10, 20, 40 t.ha-1) + control. Pots were seeded with Italian ryegrass (Lolium multiflorum) and watered to keep soil moisture above 70% field capacity. After 138 days trial, soil properties were analysed for SOM and its physical fractionation, total C and N, extractable K, P Olsen, pH, effective cation exchange capacity (CEC), bulk density, porosity, field capacity, and aggregate stability.

Multivariate analysis showed that compost dose had a stronger influence on soil properties than compost type. Linear regression revealed that SOM, total C, extractable K, pH and effective CEC increased proportionally with dose. The highest dose led to SOM and total C increases of 13.3 and 8.4 $g \cdot kg^{-1}$, respectively. Compared to HMC, OPCs were better K sources. Organic amendment decreased bulk density (by 8-15%) and increased soil porosity, field capacity, and improved aggregate stability by ~20% (particularly with OPC31 and OPC44).

OPC application also enhanced both physical and chemical protection of SOM. C content was highest in macroaggregates, stored as unprotected and coarse particulate OM. Higher doses — especially of OPC31 and OPC44 — promoted larger C accumulation in strongly physically and chemically protected pools, as compared to control and HMC. OPCs application increased mineral-associated OM, likely due to their colloidal nature, supporting long-term SOM stabilization.

This study highlights the potential of OPC to improve SOM content, fertility, and soil structure in degraded Mediterranean soils. Composting OP provides a sustainable approach to valorise agri-waste, enhance soil functions, and support climate-smart agriculture.

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GT 09 - 171 - O

EFFECTS OF LAND USE, AGGREGATE SIZE AND SOIL DEPTH ON AGGREGATE STABILITY AND ENZYMATIC ACTIVITIES IN A SILVOPASTORAL SYSTEM

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Silvopastoral systems have gained recognition as sustainable land management strategies by integrating trees and pastures, promoting biodiversity, increasing carbon sequestration, and reducing erosion [1]. In these systems, soil quality is strongly influenced by its physical structure and biological activity. Soil aggregates are fundamental units of soil structure, which is directly linked to organic carbon storage and significantly affects microbial habitats, soil stability, and the biogeochemical cycles of carbon (C), nitrogen (N), and phosphorus (P) [2].

This study aimed to evaluate the effects of aggregate size, tree density, soil depth and land-use conditions on (I) aggregate stability and (II) enzymatic activities: urease (N cycle), β-glucosidase (C cycle), and phosphomonoesterase (P cycle) and (III) soil bacterial communities.

The experiment was conducted on the private property of Bosques Naturales S.A. (Boimorto, Spain), specifically in a plantation of hybrid walnut trees (Juglans major MJ209 × J. regia), under two planting densities (625 and 277 trees ha^{-1}). Control of adventitious vegetation was carried out through extensive sheep grazing. Soil samples were collected from three areas: under tree rows, in open pasture, and in grazing exclusion plots. Samples were taken at two depths (0–15 cm and 15–30 cm) and separated into three aggregate size classes (0–1 mm, 1–2 mm, and 2–4 mm). Aggregate stability, the activities of the enzymes and the taxonomical composition of the bacterial soil communities through 16S DNA metabarcoding were analysed.

The results demonstrate that aggregate stability and enzymatic activities are directly affected by land use and changes in tree density. Therefore, sustainable management strategies that reduce physical disturbances may also positively influence both the physical and biological indicators of soil health.

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GT 09 - 181 - O

CENTER FOR CARBON RESEARCH IN TROPICAL AGRICULTURE (CCARBON): RESEARCH AND INNOVATIONS ON SOIL HEALTH

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Healthy soils are essential for sustaining food, feed, fiber and (bio)fuel productions, as well as other critical ecosystem services and human well-being. Therefore, soil health (SH) is the foundation for food security, especially in tropical regions that are more vulnerable to climate change. To address this challenge, the Center for Carbon Research in Tropical Agriculture (CCARBON) of the University of São Paulo was created in 2023. The aim here is to introduce CCARBON and its major advances in soil health (SH). The CCARBON’s mission is to develop innovative solutions and strategies for carbon-based sustainable tropical agriculture to mitigate climate change and improve living standards and conditions. Our vision is to be recognized as a world-class center, a leader in low-C tropical agriculture, and qualification of human resources. To achieve the CCARBON’s goals, strategic, multidisciplinary, and innovative research lines cover five major areas: soil, plant, animal, atmosphere, and digital tools. For that, CCARBON has associated more than 70 researchers. Specifically, on SH area, CCARBON has promoted several strategies of research, dissemination and innovation. Regarding research and innovation, the main focus is quantifying the impact of regenerative agriculture on SH, crop yield, and resilience to climate change. In addition, methodologies have been developed, including on-farm SH assessments (e.g., SOHMA KIT® patent application - BR 102024 015629-3), computational systems for SH indexing, and large-scale SH mapping (i.e., the first SH map for Latin America and Caribe, was just published). In terms of governance, in April 2024, we launched the Brazilian Soil Health Partnership (BSHP), a national alliance to promote the SH agenda (https://brsoilhealthpartnership.com/). The BSHP is associated with CCARBON and has brought together 50 researchers from all Brazilian regions. The main objectives of this scientific network include the standardization of sampling protocols and the analysis of SH indicators, the definition of a minimum set of indicators, and SH benchmarking studies involving the main crops and pedoclimatic conditions. In addition, the BSHP is starting to play an important role in extension/outreach and advocacy activities to promote SH principles and support initiatives and policies on SH and soil conservation. The results will pave the way for increased sustainable food production in tropical agroecosystems and promote social development in the coming decades.

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GT 09 - 199 - O

FROM FERTILITY TO FUNCTION: THE EVOLVING NARRATIVES OF SOIL HEALTH AND QUALITY

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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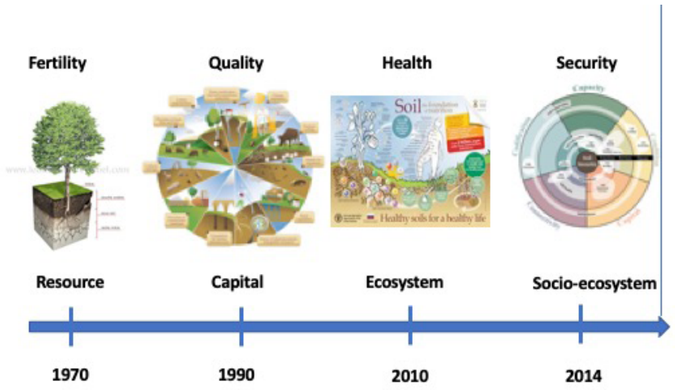
There is currently a degree of confusion-even ambiguity-surrounding the terms “soil health” and “soil quality.” Yet these two concepts have distinct historical trajectories that mirror the evolving perception of soil within both academic and societal spheres. Over the past decades (from the 1970s to the 2010s), the view of soil has shifted from a mere physical substrate for plant production to a more complex understanding of soil as a multifunctional ecosystem, and even as a socio-ecological system. The concepts of soil health and quality were preceded by that of soil fertility, which emerged in the 1970s and reflected a reductionist vision focused on agronomic performance and the benefits derived from soil exploitation. This approach largely overlooked the intrinsic value of soil as a complex ecosystem. By the late 1990s, in response to growing environmental concerns, the concept of soil quality emerged, broadening the perspective to encompass soil multifunctionality and the provision of ecosystem services. Early definitions were rooted in a functionalist approach, aligned with the conceptual framework of ecosystem services. The notion of multifunctionality, introduced in the early 2000s, only gained widespread traction in the scientific literature after 2017.

Meanwhile, the concept of soil health gained popularity in scientific discourse from the 2010s onward. However, the metaphor of soil health is not new: it dates back to antiquity, with Hippocrates referring to the earth as the “stomach of plants” as early as 460 BCE. The first scientific mention of the term appeared in 1910 in Henry A. Wallace’s thesis. Thus, the history of soil health is both older and more intricate than that of soil quality. Furthermore, the concept of soil health carries a geographical dimension. The European perspective is closely linked to the idea of “living soil,” present since the 1930s, while the Anglo-Saxon view is more centered on sustainability and ecosystem resilience, notably shaped by the legacy of the Dust Bowl.

Despite the apparent proximity of their definitions, each term-soil quality and soil health-has its own history, lexical field, and scientific scope. Both concepts face similar criticisms from the scientific community, including their subjective and sometimes metaphorical nature, and the challenge of comparing soils across different contexts. However, the choice between these terms is not scientifically neutral and carries important societal implications. This presentation will analyze the analogies and differences between these concepts, highlighting that their use reflects distinct scientific and societal stakes.

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Temporal evolution of soil perception

GT 09 - 206 - O

ARE ALL SOIL HEALTH SCORES QUANTIFIED EQUALLY? A SYSTEMATIC REVIEW, CLASSIFICATION AND COMPARISON OF SOIL HEALTH METHODOLOGIES.

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil health is the ability of soils to provide vital ecosystem services like agricultural production, climate mitigation and water purification without meaningful trade-offs[1,2]. However, soil health is jeopardized by climate change and land-use pressures, threatening these services worldwide[3,4]. Quantifying soil health could prevent future degradation by providing critical information to nudge management practices and farming systems towards better environmental stewardship. However, no consensus exists on how soil health is quantified or monitored[5]. This review explores different elements of soil health quantification methods and how these elements affect soil health. In total 199 studies were reviewed and their methods were categorized into a soil health typology with twelve variables. Clustering the studies by typology variables identified four clusters of assessment methods, namely The scoring function cluster, the modelling cluster, the expert judgement cluster and the multifunctionality cluster. Subsequently, a cross-validation was done between six representative soil health assessment methods. The soil health scores of the selected methods had low correlations and agreement scores, indicating that these methods do not provide a comparable soil health score. Researchers and policy makers should be aware of the purpose of their soil health assessment and select a corresponding method to correctly interpret the results accordingly. We argue that a single combined metric for soil health should be avoided as trade-offs between soil functions occur, cannot be determined in a combined metric. We define three different purposes for soil health assessments: Large scale mapping of soil health, assessment of local soil functions and small scale comparison of indicators. We make recommendations on how soil health can be quantified for these goals using the typology framework developed in this paper.

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GT 09 - 230 - O

SOIL CARBON, FERTILITY, AND HEAVY METAL CONTENT UNDER DIRECT SOWING AND ORGANIC FARMING IN SPANISH RAINFED CEREALS

GT 09. SOIL HEALTH / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil organic carbon is a key indicator of adequate soil functionality and health. Agricultural management practices have a significant impact on this soil indicator and at the same time affect fertility and heavy metal content in soil. In semi-arid regions, soil health is threatened due to the low content in organic carbon, among other reasons. For that, direct sowing and organic agriculture are proposed as alternatives to conventional agriculture (based on frequent tillage and dependent on chemical inputs). These practices are of particular interest in countries located in semi-arid regions such as Spain, where one of the predominant agro-ecosystem is rain-fed cereals. This study evaluates the effect of soil management on organic carbon content, soil fertility and heavy metal content in soil in 5 regions of Spain. For this purpose, around 300 rain-fed cereal fields managed under three types of management, conventional agriculture, direct sowing and organic agriculture, were selected. Soil sampling was done in 2023, collecting samples from the shallowest soil horizon (0-20 cm) where roots are concentrated in cereals. The results showed that direct sowing and organic agriculture increased soil organic carbon levels, having a different impact on the bases of the exchange complex and on the availability of macronutrients (N, P and K), related to conventional agriculture. Additionally, total Pb and Zn content in soil was increased with organic agriculture and Cu with direct sowing, while Cr was reduced with organic agriculture, in comparison with conventional agriculture, but As and Ni were not significantly modified. Certain soil properties, i.e., soil granulometry, soil pH, and soil mineralogy, and environmental variables such as latitude and mean annual precipitation played a key role in the impact of direct sowing and organic agriculture on organic carbon, fertility and heavy metal content. The results obtained in this study highlight the capacity of these agricultural practices, considered as more sustainable than conventional agriculture, to regenerate the health of rainfed cereal agroecosystems. Adopting practices such as direct seeding and organic farming contributes to increasing soil carbon and improving the resilience of agriculture, aligning it with national and European sustainability policy-strategies.

ACKNOWLEDGEMENTS

This study was funded by the SOILBIO project supported by the Biodiversity Foundation of the Ministry for Ecological Transition and the Demographic Challenge (MITECO) in the framework of the Recovery, Transformation and Resilience Plan (PRTR), funded by the European Union - NextGenerationEU. Antonio Rafael Sánchez-Rodríguez is funded by the Spanish National Research Agency through the Severo Ochoa and María de Maeztu Program for Centers and Units of Excellence in R&D (Ref. CEX2019-000968-M), as well as by the Ministry of Science and Innovation (Project PID2023-149247OB-C22, SOPHOS).

GT 09 - 234 - O

SOIL MANAGEMENT IMPACTS ON SOIL STRUCTURAL PROPERTIES IN TEN EUROPEAN LONG-TERM EXPERIMENTS.

GT 09. SOIL HEALTH / GT 05. SOIL HYDROLOGY & EROSION

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Soil structure plays a crucial role in determining functional soil properties essential for crop growth, including water infiltration, water retention, and mechanical resistance, which directly impact water availability to crops and accessibility of resources by roots. Soil management affects soil structure directly through loosening by tillage and traffic compaction, as well as indirectly, for example by influencing soil organic carbon (SOC) content, earthworm abundance and activity, and root growth. In the SoilX project, we evaluated how soil hydraulic and mechanical properties respond to differences in soil management. Our assessments encompassed measurements of saturated and unsaturated hydraulic conductivity, water retention, aggregate stability, and penetration resistance in the topsoil and in subsoil layers. In addition, we measured earthworm abundance and visually assessed the soil structural quality. Basic soil properties including texture and SOC were also measured. We sampled over 100 experimental plots across ten long-term field experiments (LTEs) in Europe. To compare soil management across LTEs, we calculated numerical soil management indicators. Preliminary data analysis of the Swiss LTEs revealed that tillage intensity had a negative and soil cover a positive impact on earthworm biomass, and that saturated hydraulic conductivity was positively correlated with earthworm biomass. Higher carbon inputs were associated with increased SOC contents, higher unsaturated hydraulic conductivity, and slightly larger amounts of plant-available water. Comprehensive analyses of data from all ten LTEs are currently on-going. The preliminary findings underscore the significant impact of soil management on soil structure and function. Quantitative relationships between soil management and soil structural properties derived in the SoilX project will help guide the development of sustainable soil management strategies aimed at enhancing soil health and resilience to climatic extremes.

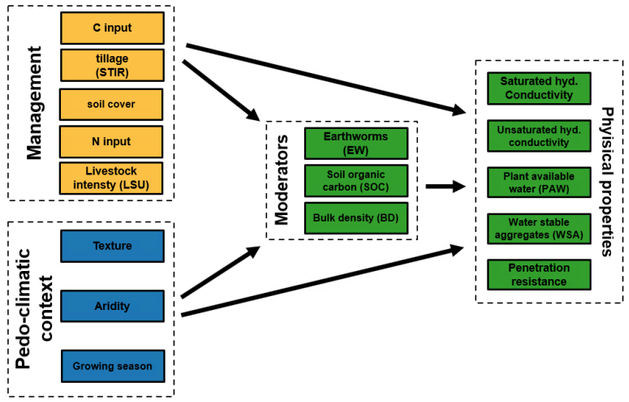
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GT 09 - 240 - O

THE AFRICA UNION SOIL OBSERVATORY (AUSO): A CONTINENTAL APPROACH TO SUPPORTING SOIL HEALTH AND AGRICULTURAL SUSTAINABILITY IN AFRICA.

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil degradation in Africa is considered one of the highest globally, largely due to high rates of erosion and nutrient depletion. The literature indicates that the trend of soil degradation has been increasing in most parts of Africa over the past decade and is projected to continue rising if no urgent corrective actions are taken. This degradation pattern is negatively affecting soil health, agricultural productivity, biodiversity, and water quality on the continent. This degradation is exacerbated by unsustainable farming practices, climate change, and population growth, leading to poor crop yields, food insecurity, and economic hardship for millions of African farmers[1]. Addressing these challenges requires accurate and accessible soil health data, which is often unavailable or hard to obtain across the continent. This hampers policymakers and researchers in monitoring soil conditions, tracking changes, and implementing targeted interventions [2].

The AUSO project aims to tackle these issues by establishing a continental African Union Soil Observatory (AUSO), which will include an African Soil Data Centre (ASDAC) and a Soil Health Dashboard to fill existing data gaps. Managed by FARA and owned by the African Union Commission, the AUSO will consolidate soil data from various national and international sources, creating a user-friendly platform for soil health monitoring. Through efforts to address soil data shortages and develop national soil health strategies in 12 countries, AUSO will empower stakeholders in the public and private sectors to make informed decisions, prioritise interventions, and support evidence-based soil and land management policies that promote sustainable agriculture.

AUSO will build on the Soils for Africa (S4A) project, which is developing a continental Open-data Soil Information System (SIS). AUSO will draw insights from the EU Soil Observatory, European Soil Data Centre and other initiatives, ensuring relevance and adaptability to the African context. The project will adopt a co-development approach, engaging stakeholders from national agricultural institutes, government departments, and other key organisations.

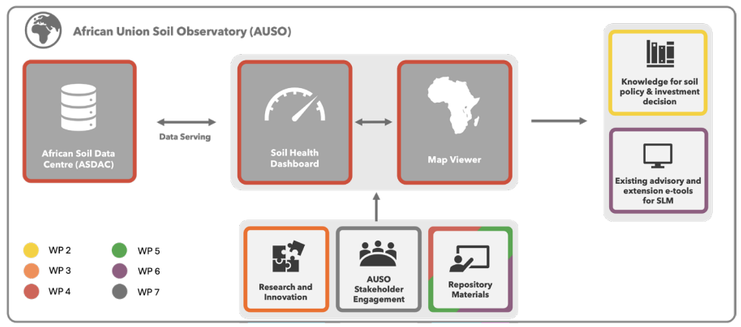
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GT 09 - 264 - O

AUTOMATING BAIT LAMINA STICK EVALUATION WITH COMPUTER VISION: A SCALABLE AND OBJECTIVE APPROACH FOR SOIL MESOFAUNA ACTIVITY ASSESSMENT

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The bait lamina test is commonly used to evaluate the feeding activity of soil fauna (Törne 1990). So far, the evaluation of bait removal is carried out through manual scoring based on visual observations. However, this approach is inherently subjective, labor-intensive, and thus susceptible to variability (Eisenhauer et al. 2014) The judgment of observers can vary based on factors like lighting, experience level, and how they interpret ambiguous bait removal. Originally, a 2-point classification system was proposed (Törne 1990). Later studies also use 3 and 5-step systems (Vorobeichik and Bergman 2021). With more evaluation steps, manual effort, and the potential for subjective differences among observers may increased.

We examined 160 sticks with three independent observers using a three-tiered classification system ("No activity", "Partial", "Full"). Discrepancies of up to 25% were noted in "partial" scores among the observers. The Intraclass Correlation Coefficients (ICC) for these categories indicate moderate and good agreements for "Partial" (ICC = 0.63) and "No Activity" (ICC = 0.80), indicating the subjectivity. We developed a new evaluation procedure using standardized photographs of 8 sticks placed on a light table and taken with standard smartphones. A Python-based computer vision pipeline is used, with Hough Circle Detection and grayscale pixel intensity analysis. This method identifies perforations, and classifies the activities in 7 classes: 0%, 10%, 25%, 50%, 75%, 90%, 100%. Results show that the activities calculated (A, with a 3-point system) resulted in strong correlations with manual observations M1 to M3 (A vs. M1: 0.74 ; A vs. M2: 0.73; A vs. M3: 0.69), which equals the correlation between the observers (M1 vs. M2: 0.76; M1 vs. M3: 0.71; M2 vs. M3: 0.74). The mean activity per plot from image analyses is between the values recorded by manual observers. The automated method enhances accuracy, eliminates subjectivity, and allows high-throughput analysis. By leveraging advances in computer vision, this workflow provides a reproducible and scalable solution for monitoring soil mesofauna activity.

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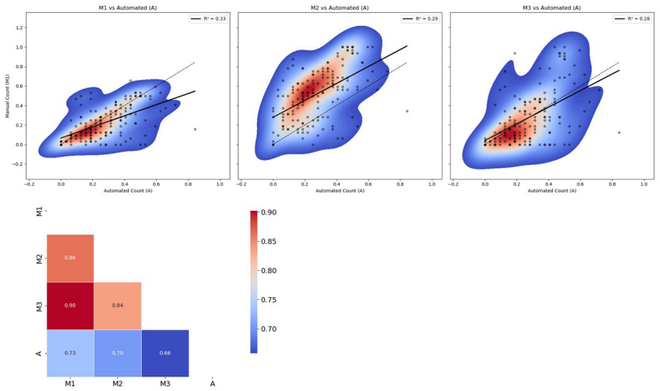


Figure: Comparison of automated and manual bait lamina evaluations across all strips. (Top) Density scatter plots showing the relationship between automated activity fractions and manual assessments (M1, M2, M3). Solid black lines represent linear regression fits; dashed lines indicate the 1:1 reference. (Bottom) Correlation matrix summarizing Pearson correlation coefficients between all manual observers and the automated system.



GT 09 - 266 - O

IDENTIFYING KEY STAKEHOLDERS IN SOIL MONITORING, REPORTING, AND VERIFICATION (MRV): AN OVERVIEW OF THE EARLY INSIGHTS

GT 09. SOIL HEALTH / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Numerous actions to preserve or restore soil health are applied by land managers such as adopting agroecological practices, de-sealing or planting trees [1,2,3]. To create an incentive for land managers to preserve and restore soils, few instruments are currently available. Among them, Monitoring, Reporting and Verification (MRV) is an emerging tool to check the effect of the practices. Since it can be used to reward the land managers, it is based on two pillars: robustness and transparency. Monitoring of the action effects is the first step that requires a scientifically robust selection of parameters and indicators and respective sampling design, feasible for the land manager or for an external organisation. It should be able to quantify results or outcomes with an acceptable accuracy and precision. Results need to be clearly reported, and sufficient information should be provided to ensure their reproducibility. Verification of results or outcomes should be done by an independent expert organisation to avoid conflicts of interests [4].

One of the key objectives of the Horizon Europe BENCHMARKS project is to develop a robust MRV approach for soil health monitoring [5]. To do so, it is crucial to review existing examples of MRVs for preserving soil health and to identify characteristics that shape decisions of stakeholders regarding the MRV components.

In this study, we identify stakeholders that implement MRVs for soil preservation and, based on this, we build a stakeholder and MRV classification. First, we sent a survey to soil experts to ask them for relevant characteristics that could affect selection by the stakeholders of the MRV components. Then, we combine three methods to identify these stakeholders by using a traditional literature review, web scraping, and a browser based on Artificial Intelligence.

Here, we will present our first results regarding the stakeholder classification and the existing MRV frameworks.

This study provides valuable guidance for future stakeholders that want to implement MRV for preserving soil health. The presented examples can help to identify and select the MRV components that fit the best with different stakeholders´ needs and their context.

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GT 09 - 301 - O

SOIL ECOSYSTEM SERVICES: LINKING CONCEPTS, ASSESSMENT METHODS, RELATIONSHIPS, AND POLICY-MAKING.

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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Soil Ecosystem Services (SES) are crucial for human well-being and socioeconomic development [1]. However, soils are increasingly threatened by both anthropogenic pressures and environmental changes, leading to the deterioration of their SES [2]. To address this challenge, a thorough understanding of soil functioning is needed, especially through the assessment of its delivered SES and the characterization of their synergy and trade-off relationships [3]. This assessment remains challenging due to ambiguities in current conceptual frameworks, and the lack of clear regulatory guidelines among concepts of soil quality, soil health, soil functions, and SES [4]. Moreover, current assessment methods often struggle with issues of scale, cost, data quality and availability, while generating uncertainties in evaluating SES [5]. This study provides a comprehensive review of the scientific literature on SES and examines the progressive integration of soils into various conceptual frameworks. It highlights the differences among existing soil-related concepts while also pointing out the methods used to assess SES, their synergy and trade-off relationships, and their associated uncertainties. Finally, this work emphasizes the importance of SES quantification in supporting public decision-making by tracing the historical soil consideration in land-use planning across different spatial and temporal scales. Overall, the assessment of SES should consider integrated conceptual frameworks and harmonized definitions of concepts to overcome existing methodological limitations. It should also combine validated biophysical protocols with a multidimensional, adaptive indicator system. The transdisciplinarity of this approach allows the quantification of synergy and trade-off relationships among SES, thereby providing meaningful support for policy development, land-use planning, and sustainable agroecosystem implementation.

Keywords: soil ecosystem services, soil properties, biophysical assessment, conceptual framework, indicators, uncertainties, review.

ACKNOWLEDGEMENTS

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GT 09 - 363 - O

SOIL MESOFAUNA AS SOIL HEALTH INDICATOR: LESSONS FROM CONSERVATION AGRICULTURAL AND FORESTRY SYSTEMS

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Soil mesofauna, characterised by their high abundance, diversity, and sensitivity to environmental changes, offer significant potential as bioindicators in assessing land management impacts. Their often-overlooked role in monitoring ecosystem health warrants greater attention, especially in the context of conservation and sustainable land-use practices.

In this study, we evaluated soil mesofaunal communities across three experimental systems designed to test conservation-oriented management strategies. These included: (1) long-term monocultures versus crop rotation systems; (2) conventional versus regenerative agricultural practices; and (3) diverse forestry treatments compared with continuous cover forestry. We aimed to determine which mesofaunal indicators, taxonomic (diversity, species richness, density) or trait-based (QBS-ar, disturbance resistance), are most informative across contrasting environments and disturbance regimes.

Our findings suggest that the utility of mesofaunal indicators varies considerably depending on land use type. In intensively managed agroecosystems, community-level metrics such as species richness and density were responsive to conservation practices. However, these same metrics were less informative in forest settings, where disturbance effects were subtler. Trait-based approaches, particularly those reflecting disturbance resistance, provided more consistent insights across habitat types and temporal scales. Our results highlight the importance of incorporating seasonal sampling when assessing soil mesofauna responses to management interventions.

In conclusion, general metrics such as density, species richness, or diversity do not always capture the differences between treatments—particularly in complex or less-disturbed systems. In contrast, in environmentally friendly agricultural contexts, the QBS-ar index emerged as a simple yet effective tool for evaluating soil health. Moreover, functional traits, especially those related to disturbance tolerance, proved to be valuable supplementary indicators, capable of detecting subtle seasonal and spatial differences that traditional measures might overlook.

ACKNOWLEDGEMENTS

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GT 09 - 369 - O

REQUIREMENTS FOR DEVELOPING A FUTURE MONITORING, REPORTING, AND VERIFICATION (MRV) APPROACH FOR SOIL HEALTH: LESSONS LEARNED FROM THE FRENCH AND GERMAN NATIONAL SOIL MONITORING NETWORKS

GT 09. SOIL HEALTH / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The European Union soil health dashboard states that 62% of soils are degraded [1]. However, a tangible assessment of soil health is still missing. Monitoring soil health is indeed very complex, because it should involve soil multifunctionality [4]. Monitoring, reporting, and verification (MRV) approaches are able to integrate soil health into policies and markets. They may be quite variable and depend on the purpose (e.g. national or local scale for policies or markets). They have three main components: 1) Monitoring- ensuring a scientifically robust sampling, 2) Reporting- providing transparent and reproducible reports of the data and the results and 3) Verification- suggesting an independent procedure. At national scale, the soil health monitoring will be carried by the already-existing soil monitoring networks. In France, the Soil Quality monitoring Network (RMQS), started in 2000 covers a large diversity of land uses and soil parameters [3]. In Germany, the German Agricultural Soil Inventory (BZE-LW) started in 2011 and is focused on agricultural areas, mainly on carbon dynamics and soil organic matter cycling [4]. In this study, we analysed the requirements to shape a future soil health MRV framework on the RMQS and the BZE-LW. We expect that the RMQS and the BZE-LW will differ regarding the soil sampling strategies, but the reporting and verification procedures would be quite close, as for both their data are mainly used for same purposes (i.e. research and national public policies). We led interviews with their coordinators using the PESTEL scheme [5] as subdivisions of the MRV framework, wherein we analyse the drivers and barriers indicative of a future soil health monitoring. The outcomes will help to identify realistic pathways for integrating new soil health indicators to the RMQS and the BZE-LW.

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GT 09 - 382 - O

SET-ASIDE LAND: A TOOL FOR SUSTAINABLE AGROECOSYSTEMS

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Set-aside land, agricultural land withdrawn from production, is increasingly promoted in Europe and supported through the EU Common Agricultural Policy (CAP), the EU Biodiversity Strategy for 2030 and the Nitrates Directive. Set-aside practices include fallowing, afforestation, and wetland restoration, with the aim to restore soil health, enhance habitat diversity, reduce nitrogen (N) losses, and increase carbon sequestration.

However, there is a lack of understanding on potential benefits and long-term effects of set-aside land and how it should be managed, especially on the influence of (i) environmental factors, such as soil type, climate, and landscape position, and (ii) management practices, including different types of vegetation, establishment methods and timing. This study was set up to investigate the effect of management practices on N leaching over a period of three years.

2. Methods and Materials

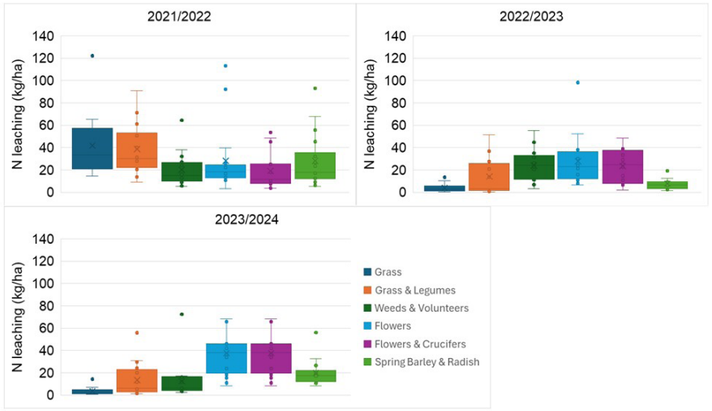
Field experiments with different set-aside land were set up in autumn 2021 in Foulum, Denmark after 7 years of winter rye cropping with different N fertilisation rates. Set-aside included (T1) pure grass, (T2) grass/legumes, (T3) weeds and volunteers, (T4) flowers, and (T5) flowers and crucifers. Treatments 1 to 3 were established after harvest of winter rye in autumn 2021, and these were cut once a year. Treatments 5 and 6 were established in spring 2022 and not cut. Leaching from these were compared to a spring barley crop with fodder radish catch crop. Leaching has, so far, been measured over three drainage periods.

3. Results

In the first drainage period (2021/2022) leaching was significantly lower under the volunteer treatments compared with the grass set-aside. This is due to the slow establishment of the grass after sowing at the end of August. In the following two years, only the pure grass treatment had consistently lower N leaching compared to the other set-aside treatments. The spring barley with catch crop had low leaching similar to pure grass in only one of the years. The grass/legume mixture, volunteers and flower treatments had generally high leaching. After the establishment year, the mean N leaching over the following two years was grass < spring barley/catch crop < volunteers (cut) < grass clover < flowers < flowers with crucifers. Poor performance of flower treatments is likely due to die off over the winter and subsequent residue mineralisation.

4. Discussion

These results over a period of three years following establishment of set-aside land indicate that managed grasses (cut at least once a year) are the best option for reducing N leaching. Poor establishment of the grass set-aside in the autumn with high N leaching losses highlights that it would be better to first sow a catch crop following the harvest of the main crop, followed by spring-sowing of grass-set aside. Including a legume in the grass mixture increased N leaching, but this would depend on the proportion of grasses and legumes in the mixture.



GT 09 - 402 - O

WHEAT ROOT TRAITS CAN TURN THE TIDE OF THE NITROGEN CYCLE IN SOIL

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The interactions between plants and soil microbial communities in the rhizosphere play a crucial role in soil productivity. In intensive crop systems, root traits that drive beneficial microbiome recruitment and improve soil structure can turn the tide on soil degradation.

Crop landraces are an untapped source of genetic diversity for the identification of advantageous root traits. The EJP Soil project WISH-ROOTS (Wheat Improving Soil Health with root traits) has screened 20 wheat genotypes (modern cultivars and historic landraces) in parallel field trials across seven countries for two consecutive years. Two regimes of nitrogen (N)-fertiliser were assessed. We focused on the identification of root traits linked to plant control of microbial nitrogen cycling and improvement of soil structure..

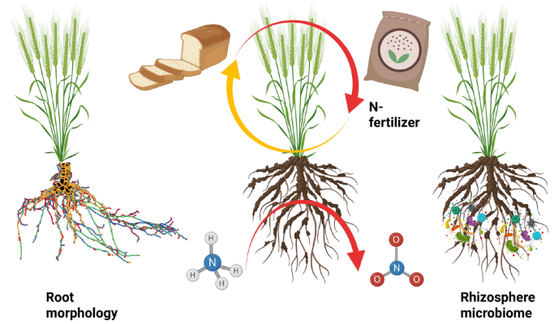
To assess wheat genotype-driven control of microbial recruitment, we analysed rhizosphere soil samples from the 20 wheat genotypes for microbiome composition (16S and ITS amplicon sequencing) using the unique sequencing technology and databases of Biome Makers Inc. Then, to determine plant nitrogen use efficiency (NUE), we measured potential nitrification rate (PNR) in the rhizosphere soil, and plant nitrogen uptake by applying 15N-enriched (NH4)2SO4 fertiliser at tillering and heading growing stages, and measuring 15N isotope analysis in the harvested seeds.

In parallel, to identify root traits that can improve soil structure, morphological root parameters were linked to soil aggregation, porosity and pore connectivity. Root morphology was assessed using image analysis with RhizoVision Explorer. Soil aggregation was assessed by wet sieving to determine the mean weight diameter. Additionally, we used X-ray tomography to assess soil porosity and pore connectivity.

We found significantly lower PNR in the rhizosphere soil of several landraces compared to modern cultivars. This was consistent with a suppression of the most prevalent nitrifying communities, Nitrososphaera and Nitroscosmicus archaea, which were identified as indicator taxa in the rhizosphere microbial network. Network differential analysis indicated an increase in resource competition in the rhizosphere of modern cultivars compared to landraces. Prediction of metabolic functions indicates higher N availability for plants and lower N microbial consumption in the rhizosphere soil of several landraces. The analysis of N content confirmed a higher NUE for those landraces compared to the modern cultivars.

We found significant differences in soil aggregation and porosity between modern cultivars and landraces, and this was correlated with root morphology, particularly root angle, length and diameter.

Our findings confirm that historic landraces modulate the recruitment and associations of microbial taxa in the rhizosphere to increase NUE and that certain root morphological traits can improve soil structure. Selective breeding for these traits can enhance soil productivity and crop performance.





GT 09 - 404 - O

ASSESSING SOIL HEALTH AND MAIZE PERFORMANCE IN SUCCESSIONAL AGROFORESTRY SYSTEMS ACROSS TWO MEDITERRANEAN FARMS

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Based in the principles of natural forests, successional agroforestry (SAF) systems offer an unique and potentially more resilient pathway to agroecosystems, compared to conventional monocropping systems. Although SAF systems have shown relevant soil improvements in tropical areas, their potential remains less understood in Mediterranean conditions. This research investigated the impact of SAF systems on soil quality, crop growth, and yields in two farms in central Portugal (Coimbra and Santarém). Both farms implemented a SAF system in 2019 and include maize cultivation, but under different edaphoclimatic conditions. Soil quality and maize growth (plant height and leaf chlorophyll content) and yield in each farm was compared to an adjacent maize monocropping field (MM). In Coimbra, a low-input and organic-certified monocropping maize was considered as control, while in Santarém the SAF system was compared with a high input conventional monocropping maize system, using a very productive maize hybrid. Soil samples were collected at two depths (0-20 and 20-40 cm), and analyzed for several physical and chemical properties, including soil water holding capacity, pH, electrical conductivity, soil organic matter (SOM) and exchangeable bases (K+, Na+, Mg2+, and Ca2+). Soil epigeic macrofauna was assessed through pit-fall trapping. The study revealed farm-dependent results, influenced by management practices and edaphoclimatic conditions. In Coimbra, SAF showed a 53% higher SOM content compared to MM (3.63% vs. 2.37%) at the soil surface, while in Santarém significant differences were found at the subsurface. Significantly higher concentrations of K+ were observed in the SAF systems at both farms compared to MM, while Mg2+ was higher in Coimbra SAF only. Conversely, Ca2+ was lower in Santarém SAF, most likely due to higher fertilization rates in the MM (3 kg CaO/ha vs. none in the SAF). Soil pH was higher in Coimbra SAF, but similar between systems in Santarém. Soil water holding capacity was higher at the soil surface in Coimbra SAF, but slightly lower in Santarém at the same depth, possibly due to soil texture variations. Epigeic macrofauna abundance was similar in Coimbra SAF when compared to an organic-certified MM (218 vs. 328 individuals), but significantly higher in Santarém SAF compared to a high-input MM (500 vs. 115 individuals). In both locations, SAF resulted in lower maize growth, associated with reduced leaf chlorophyll, lower nitrogen leaf content, shorter plant height, and consequently, lower maize yields compared to the respective MM (1.75 vs. 3.25 ton/ha in Coimbra; and 2.14 vs. 13.09 ton/ha in Santarém). These findings underscore the context-dependent nature of SAF performance with the two farms revealing distinct outcomes. These divergent results highlight that the effectiveness of SAF can be strongly influenced by soil type, climate, and management practices, requiring tailored strategies to optimize their ecological benefits.

GT 09 - 405 - O

IS ORGANIC FARMING A PATHWAY TO CLIMATE-RESILIENT SOILS?

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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With the adoption of the EU Nature Restoration Regulation in 2024, the restoration of agricultural ecosystems and the promotion of soil health have gained increasing importance. Increasing soil organic carbon (SOC) stocks in cropland mineral soils is one key measure to restore and ensure soil fertility. However, as indicated by several studies, climate change may cause SOC losses (Crowther et al., 2016; Poeplau & Dechow, 2023) leading to a need for climate resilient and soil health ensuring arable systems. In this study we compared SOC and total nitrogen (Nt) contents as well as C/N ratios and pH value of organically and conventionally managed cropland soils in Bavaria. Previous findings are mostly based on experimental results, often assuming idealized organic and conventional farming systems (García-Palacios et al., 2018; Leifeld & Fuhrer, 2010). However, such a strict separation of systems is not always reflecting practice, as conventional farms may also incorporate ecological principles into their management. A comprehensive dataset of the Soil Organic Matter (SOM) Monitoring Program of the Bavarian State Research Center for Agriculture was used as a data basis, containing SOM and management data from around 280 cropland plots distributed throughout Bavaria. All plots where initially sampled between 2001-2008 and resampled between 2011-2018. Around 60 of the study sites where organically managed for at least 10 years with 45 of them being organically managed for at least 20 years. To account for the influence of site conditions on SOC the data set was stratified according to soil texture and climatic parameters, including temperature and precipitation. The hypotheses examined were (1) if organically managed cropland has higher SOC and total nitrogen (Nt) contents compared to conventionally managed cropland and (2) if SOC and Nt changes between initial sampling and resampling are varying between the two management systems. If organic farming enhances soil SOC accumulation and preservation more than conventional farming, then expanding organic farming in its current form could improve the climate resilience of cropland soils.

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GT 09 - 426 - O

INTERCROPPING AND BIOPESTICIDE USE IMPACT SOIL MICROBIAL, MYCORRHIZAL RESPONSES AND PLANT DAMAGE IN ORGANIC MAIZE–COTTON SYSTEMS IN WEST AFRICA

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Intensive agriculture has led to strong soil degradation and the build-up of pests and pathogens. These issues are especially critical in developing countries, where agriculture faces low profitability, climate risks, and poor access to mechanization. Intercropping, known as the cultivation of two or more crops on the same land, has shown potential to improve resource use, maintain yields, and build more resilient systems.

This research explores the agroecological benefits of intercropping cotton-maize rotations with soybean under organic management in Benin. The experiment followed a randomized complete block design with several treatments, such as soybean intercropped with maize and biopesticide applications, and focused on two main aspects: soil health and pest management. Soil health was evaluated through microbial functional diversity (MicroResp™), enzymatic activity, arbuscular mycorrhizal fungal colonization, labile carbon, soil organic carbon, and mineral nitrogen. Pest management was evaluated using the Score Davis Scale based on plant injury metrics.

Preliminary results show that, after two cropping seasons, maize-soybean intercropping improves soil microbial activity (microbial catabolic profile and enzymatic activity) compared to monocropping, especially in absence of biopesticides. However, arbuscular mycorrhizal fungal colonization increased in monocropping compared to intercropping. Biopesticides reduced mycorrhizal fungal colonization in intercropped systems, but not in monocropping. Soil organic carbon levels was higher in intercropping compared to monocropping. In addition, a negative correlation was observed between arbuscular mycorrhizal fungal colonization and plant injury: mycorrhizal fungal colonization increased as the plant injury level decreased, particularly in intercropping plots. This relationship suggests a potential role of arbuscular mycorrhizal fungi in enhancing plant protections against pests.

Further analysis on plant damage and pest pressure will help clarify the trade-off between pest management and soil health under organic management. Continued long-term research on maize-cotton intercropping will offer valuable knowledge for adapting sustainable practices to smallholder farming systems in developing countries.

GT 09 - 439 - O

OF AGGREGATES AND PORES: A MULTI-METHOD FRAMEWORK TO ASSESS SOIL STRUCTURE AND FUNCTION ACROSS LAND-USE AND TEXTURE GRADIENTS

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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To address the growing challenge of soil degradation across diverse land uses, the development of robust indicators that accurately reflect soil health status is essential. Soil structure plays a central role in regulating processes such as nutrient dynamics, carbon cycling, root growth, biological activity, and rainfall partitioning influencing susceptibility to erosion. Consequently, structural attributes are considered promising indicators of soil health. Yet, assessing soil structure comprehensively remains difficult, as conventional metrics present methodological limitations and often fail to capture the full complexity of the soil system.

In response to these limitations, we adopted a multifaceted perspective on soil structural assessment, integrating three complementary dimensions. Specifically, we combined pore-scale analysis via X-ray computed tomography (CT) to quantify macropore size distribution and connectivity, in-situ aggregate-scale assessment through the Visual Evaluation of Soil Structure (VESS), and functional evaluation through measurement of soil hydraulic properties, such as saturated hydraulic conductivity.

We sampled in 88 sites covering the full range of soil textural variation across three different land-use types: arable land, grassland, and forest. Furthermore, sites were selected that shared similar texture but differed in their soil organic carbon to clay ratio (one high and one low) that is often used as soil health indicator. At each site, four 250 mL cylindrical topsoil samples (5–10 cm depth) were collected for CT scanning (macropores ≥ 91 µm radius) and measurement of soil hydraulic properties. Aggregate structural quality was visually assessed directly in the field using the VESS protocol.

The three land uses could be well characterized by their soil structural properties. CT scanned macroporosity aligned well with measurements of hydraulic properties in the wet range. VESS grades were related to unsaturated hydraulic conductivity, indicating that the VESS-method captures intra-aggregate pore connectivity and is thus a useful tool for structural evaluation and soil health assessment. Basic soil properties, such as textural class, define the boundaries of achievable values of structural attributes.

By combining visual, structural, and functional assessments, this integrated framework assesses the soil health status within texture-based boundaries with direct implications for sustainable land management and ecosystem service monitoring.



INDEX

GT 09 - 454 - O

MOVING PAST METRICS: A DATA-DRIVEN STRATEGY FOR RESTORING SOIL HEALTH AT SCALE

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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The concept of soil health has made the leap from academia to popular culture, and is influencing farmer practices around the world. Given it's broad adoption, it can be a powerful tool to achieve desired outcomes including moving agriculture towards more sustainable practices. This requires aligning metrics with outcomes including yield, efficiency, and grower profitability. We conducted a meta-analysis to test the link between dynamic, responsive soil parameters with yield. We found that generalized indicators of microbial activity including dehyrdrogenase activity and microbial biomass carbon had the strongest correlation with yield. New indicators such as POX-C and soil protein outperformed soil organic matter content, pointing towards new targets for improving soil health for better outcomes. In a separate analysis, we used long-term satellite records of EVI at 250m resolution to identify hotspots of declining productivity that may be linked to declines in soil health. We are currently testing several solutions that can enable soil health practices and directly improve soil functionality. Together, these insights enable us to design and test an explicit theory of change to address soil degradation and restore soil health at scale.

GT 09 - 507 - O

HARMONIZATION OF SOIL HEALTH DATA

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Harmonization of Soil Health data

For the upcoming Soil Monitoring and Resilience Directive, comparability of soil data across Europe is paramount. Soil Health as such is not a measurable characteristic. It is a generic term to describe in a holistic way whether the soil can provide the ecosystem services it potentially could deliver. Still, neither ecosystem services are directly measurable. It asks for appropriate monitoring data and the assessment of these data to determine the soils functions.

Collecting soil data is unfortunately complex. Seven key steps can be identified in that process, which all need to be considered to obtain results that are fit for purpose: the definition of the investigation, sampling, transport of the samples, preparation of the test portion, analysis, assessment and reporting. And each of those steps has its own associated uncertainty. Due to differences in the soil characterization process, similar measurements can result in incomparable results. To establish a common vision on the soil health in Europe, harmonization of methods should therefore be reached.

The European Technical Committee CEN/TC 444 – Environmental characterization of solid matrices, works on the development and maintenance of European standards for soil and other solid matrices. Through validated European standards, the performance characteristics of the key steps of the characterization process are known. Adoption of those methods throughout Europe implies a harmonized approach and data that are indeed comparable.

Despite the fact that some 125 EN-standards for soil characterization have already been developed, both the upcoming Soil Monitoring and Resilience Directive as well as some of the societal challenges we're facing still asks for additional characteristics to be measured (e.g. microplastics, PFAS, soil life). A process in which also your expertise can be of vital importance!

ACKNOWLEDGEMENTS

On behalf of CEN/TC 444 - Environmental characterization of solid matrices



GT 09 - 520 - O

MONITORING SOIL FUNCTIONALITY IN TWO CROP TYPES -ANNUAL MAIZE AND PERENNIAL GRASSLAND- UNDER DIFFERENT AGRONOMIC MANAGEMENT PRACTICES

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The EU Soil Strategy for 2030 outlines a comprehensive framework and concrete actions to protect, restore, and ensure the sustainable use of soils. As part of this initiative, a new Soil Health Law has been proposed, aiming to deliver a high level of environmental and public health protection. This law emphasizes monitoring soil conditions—particularly at the local level—to support informed decision-making and enables the development of targeted solutions to emerging challenges.

Agricultural systems provide significant ecological value, particularly in the context of climate change adaptation and mitigation. These ecological benefits can also be translated into economic value, for instance, through payments for ecosystem services under the Common Agricultural Policy (CAP). However, while agronomic practices support productivity, they may also negatively impact soil health. One such concern is the contamination of soils with antibiotics, primarily stemming from livestock farming. A large proportion of antibiotics administered to animals is excreted unmetabolized via feces and urine, introducing both residual antibiotics and antibiotic-resistant bacteria into the environment. This contributes to the spread of antibiotic resistance genes, posing a risk to both environmental and human health.

In this study, we investigated two crop systems located in the region of Galicia (NW Spain):

(i) Perennial grasslands under both conventional and ecological management, and

(ii) Annual crops, with and without crop rotation.

Soil samples were collected from the top 20 cm in spring and winter 2023, and again in spring 2024, in the Galicia region of northwest Spain. These samples were analyzed for a range of soil chemical and biological health indicators. Chemical parameters included pH, cation exchange capacity (CEC), total and dissolved carbon and nitrogen, and metal availability. Biological indicators encompassed the microbial physiological fingerprint, assessed via Biolog Ecoplates (carbon source utilization), as well as soil enzyme activities (urease and β-glucosidase).

In addition, we present findings on culturable soil bacterial strains isolated from both conventional and ecological grassland systems. These strains were tested for tolerance to copper (Cu), ampicillin, and tetracycline, shedding light on the presence and potential spread of antibiotic-resistant bacteria in different agricultural contexts.

ACKNOWLEDGEMENTS

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GT 09 - 533 - O

SECOND-ORDER META-ANALYSIS TO ASSESS THE GLOBAL EFFECTS OF AGROFORESTRY ON SOIL HEALTH

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Agroforestry (AFS), the integration of trees into farming systems, offers a promising strategy to enhance agroecosystem functions and address climate change. Its strength lies in the capacity of trees to exploit both surface and subsurface resources beyond the reach of crops, while also contributing to the rehabilitation of degraded farmland through increased above- and below-ground organic matter inputs. However, the observed effects of AFS on these functions are known to vary depending on pedoclimatic conditions and the specific types of AFS implemented and specific soil-related process considered. Here, we detailed the effects of AFS compared to treeless agricultural systems on a global scale based on a second-order meta-analysis, synthesizing findings from 1’500 primary studies and 26 relevant meta-analyses identified through Web of Science, Scopus, and prior systematic reviews. Each meta-analysis was evaluated using standardized quality criteria, and the overlap of primary studies was analysed to assess the independence of the evidence base. The MA quality scores ranged from 25% to 100%, with over half of the MAs having a score of 75% or higher. However, half of the MAs didn’t weight individual effect sizes or perform any heterogeneity or publication bias analyses. We developed a knowledge gap map for soil and water-related outcomes, highlighting well-covered topics in the literature and identifying areas needing further research. Our findings indicate that AFS generally improves soil carbon (28% [19-37% 95%CI]), and enhances both chemical (37% [17-59% 95%CI]) and biological soil quality (59% [1-152% 95%CI]). Soil carbon parameters (SOC stocks and content) are increased regardless of practice type and pedoclimate, except in arid pedoclimates where soil carbon is estimated to increase by up to 77% [24-121% 95%CI] %), though data paucity in these areas limits the reliability of these estimates. Improvements in physical soil quality (37%, [8-74% 95%CI]), erosion control (183%, [53-423% 95%CI]), and water retention (73%, [63-83% 95%CI]) were also observed, albeit with less robust evidence due to effect heterogeneity and limited meta-analytic coverage. While the broad scope of this second-order meta-analysis restricts conclusions to aggregated indicators rather than specific soil processes, it offers a global quantitative perspective on the benefits of AFS for soil health and water conditions. This work also assesses the reliability of existing meta-analytic evidence and provides a basis for scaling up AFS practices, supporting informed decision-making for the implementation of different AFS practices across different environmental contexts.



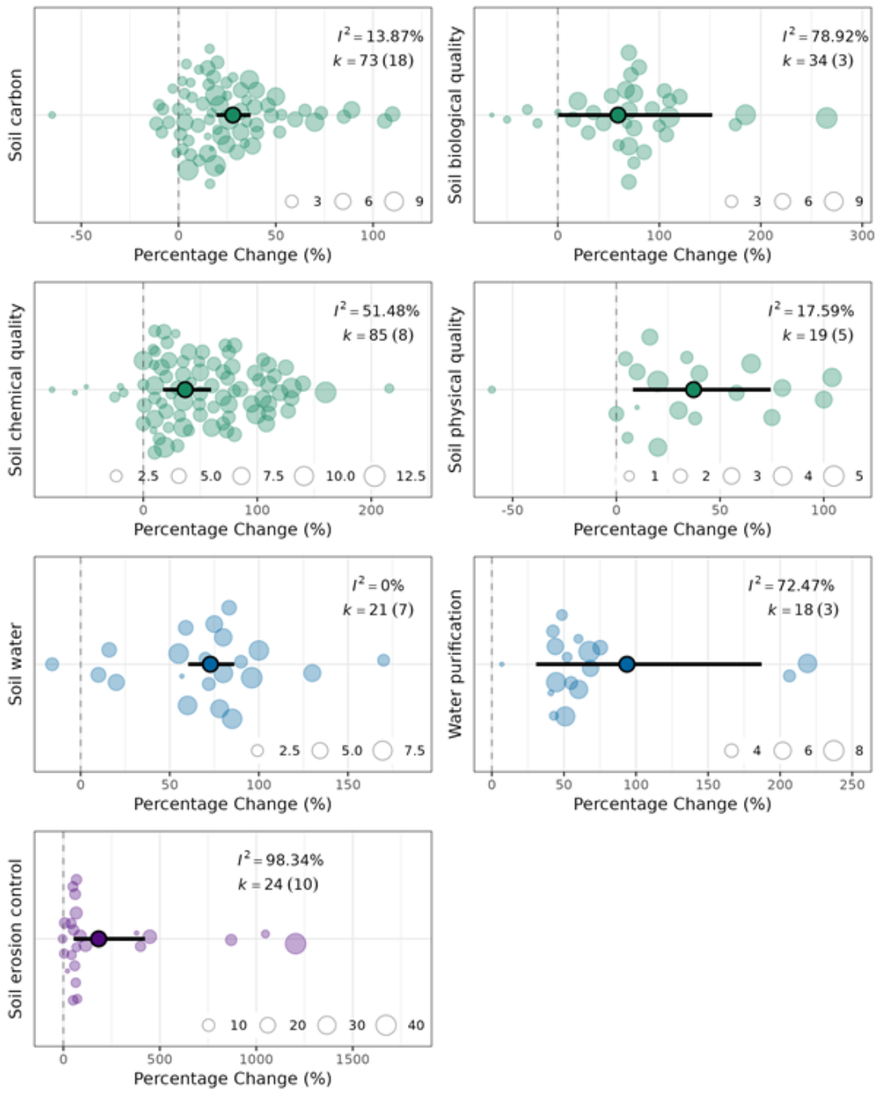


Figure 1: Overall mean effect and 95%CI of agroforestry systems compared to tree less agricultural systems on different groups of soil parameters.

GT 09 - 551 - O

SOIL UNDER PRESSURE: WHAT TERRESTRIAL ISOPOD AGGREGATION PATTERNS REVEAL ABOUT ECOSYSTEM HEALTH

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil ecosystems are increasingly subjected to various degradation processes. The main driving forces include abiotic factors (such as temperature, soil moisture, salinization, and pH), biotic factors (including synnecrotic interactions, responses to necromone signals, and shifts in the soil microbiota diversity and composition), and anthropogenic stressors—primarily chemical and physical contamination. This underscores an urgent need for rapid and ecologically relevant indicators that can indicate the integrity or degradation of soil ecosystems. Among these, the behavioral responses of terrestrial isopods such as Porcellionides pruinosus can provide valuable insights into soil quality by reflecting changes in population structure and dynamics. As a gregarious species, P. pruinosus exhibits population-level responses under stress, including avoidance behavior and alterations in group density. This study introduces a novel ecological endpoint—the disaggregation effect—observed in P. pruinosus individuals exposed to various stressors. Changes in aggregation among groups of ten individuals were assessed using a 48-hour sublethal test. The Disaggregation Index (DI) is proposed as an ecological indicator to quantify the fragmentation of the population into subgroups in response to disturbance. The DI index ranges from 0 to 1, with 0 representing maximum aggregation and 1 indicating total disaggregation. A threshold of 0.5 was established, above which more than 50% of the population is considered fragmented. All tested stressors elicited marked changes in social behavior. Physical (tire particles) and chemical (sodium chloride, 1,3-dichloropropene and dichlobenil) contaminants induced strong, dose-dependent disaggregation responses, as did most biotic factors (competition and necromone responses). Interestingly, temperature and soil moisture triggered U-shaped responses, with disaggregation occurring at both low and high levels. In contrast, pH did not induce fragmentation but enhanced aggregation at both pH extremes. In conclusion, the disaggregation endpoint shows high potential for assessing the impact of diverse soil stressors on the social structure of terrestrial isopod populations. It provides a quick, affordable, and environmentally relevant tool for assessing soil quality and examining the biological impacts of environmental disruptions on social invertebrates.

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GT 09 - 567 - O

TOWARDS ROBUST ASSESSMENT CRITERIA FOR SOIL BIOINDICATORS: INSIGHTS FROM EUROPEAN CASE STUDIES

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The new EU Soil Strategy sets an ambitious objective: to fully restore soil health across Europe by 2050. To evaluate progress towards this goal requires harmonized monitoring frameworks that incorporate policy-relevant indicators, supported by scientifically robust assessment criteria. Biological conditions are central to soil health, and under the proposed EU Soil Monitoring Law Member States will be required to implement soil bioindicators to describe soil functioning and biodiversity loss. However, at present only few Member States have established evaluation criteria—such as target or threshold values—for interpreting monitoring data.

This study explores the challenges and opportunities involved in defining such criteria. Using exemplary data from national or regional monitoring across several countries across Europe (France, Switzerland, Italy, Spain, Netherlands, Sweden), we derive 'normal operating ranges' (NORs) for six commonly used soil biological indicators (microbial biomass and relative abundance, soil enzymes, nematodes, microarthropods, earthworms), taking into account variations in soil texture and land use.

Leveraging on these national case studies we identify the feasibilities and challenges for elaborating, and comparing assessment criteria for soil biological indicators for national and EU-scale soil health monitoring.

We find that for most bioindicators, criteria could not be defined due to limited data availability and environmental bias (e.g heterogeneity of evaluation units and definition, heterogeneity of sampling protocols and data aggregation methods). Considering our data, France is the only country where NORs have been established for earthworms, and still only for certain soil units. Our study identifies data gaps and priorities for research and policy implementation of soil biological data in soil health conservation and management.

As a temporary solution to optimize and improve the efficiency of soil monitoring programs, we propose guidelines to address data deficiencies and pseudo-replication issues. For the longer term, our findings underline the need for integrated data systems and standardized monitoring frameworks for monitoring bioindicators to evaluate progress towards achievement of the EU soil health objectives.

ACKNOWLEDGEMENTS

EJP-Soil Minotaur project

GT 09 - 578 - O

TURNING SOIL SCIENCE INTO ACTION: A PATHWAY TO ACHIEVE AGRICULTURAL SUSTAINABILITY IN LINE WITH THE SDGS

GT 09. SOIL HEALTH / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Soil testing, almost celebrating its centenary in the Netherlands, has traditionally focused on optimizing fertilization and crop yields. In recent years, however, the concept of soil health testing has gained traction, reflecting growing recognition of soil's multifunctionality and its important if not essential role in contributing to ecosystem services aimed at sustainable development, such as producing healthy crops, providing clean water, mitigating climate change and preserving biodiversity and soil health. The Dutch Soil Science Society has for a period of 90 years supported efforts to recognize this important role of soils in a societal context. Soil health is determined by physical, chemical, and biological indicators with corresponding thresholds that support ecosystem services determining sustainable land use as characterized by several UN Sustainable Development Goals (SDGs 1, 2, 3, 6, 12, 13, and 15). Despite its significance, comprehensive soil health testing remains underutilized due to challenges related to complexity, standardization, and cost.

To overcome that limitation, a rapid, standardized soil health assessment tool – the soil health indicator (SHI)- has been introduced, based on Near-Infrared Spectroscopy (NIRS) and multi-nutrient 0.01 M $CaCl_2$ extraction to assess soil chemical and biological indicators for soil health, including bio-available heavy metals.

The soil characteristics of the SHI-report are used in several monitoring studies in the Netherlands (Figure 1), but the SHI can - together with soil physical indicators for soil structure, soil moisture regimes, and crop-protection residues analysis -, also be used to generate data for Living Lab case studies, where scientists, extension services, and farmers co-design and implement sustainability strategies. Farms that meet defined thresholds for ecosystem services, that include soil health, become "Lighthouses", exemplary models that inspire replication in similar agroecological zones (Figure 2). Soil health provides major and crucial contributions to other ecosystem services, as mentioned above. Once all ecosystem services are satisfied, the land user is free to follow his own unique management practices independent of current environmental rules and regulations that focus on required forms of management procedures. But such a sustainability-focused program can only be successful when embraced by land users and methods and procedures should therefore be as simple and transparent as possible while costs should be in line with expected advantages to be obtained.

Policies should therefore focus on achieving thresholds of a set of indicators rather than on prescribing certain top-down management measures.

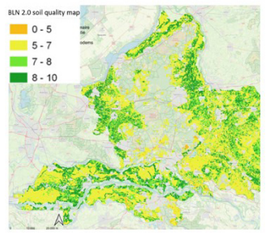


Figure 1. By using Soil Health Indicator data combined with soil maps (BLN2.0), soil quality maps can be generated. This example shows how the BLN 2.0 data has been combined to create a soil quality map for the province of Gelderland.

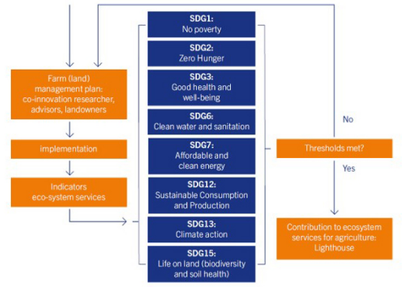


Figure 2. Flow chart demonstrating the procedure to test whether ecosystem services, contributing to achieving SDGs meet their thresholds. Soil health is an important ecosystem service by itself (SDG15) but also contributes to all the other ecosystem services in different ways.



GT 09 - 603 - O

SOIL ENZYME ACTIVITY RATES AS SENSITIVE INDICATORS OF SOIL HEALTH FOR OAK DECLINE IN RESPONSE TO DROUGHT, REWETTING AND NUTRIENT STRESS

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The ability of forests to continue mitigating climate change depends on their ability to resist, adapt and be resilient to global change drivers and pests and diseases. Temperate oak health deterioration, a significant concern in the UK and Europe, is a complex decline, where multiple interacting environmental and biotic stressors weaken trees over time, increasing their susceptibility to opportunistic pests and diseases and ultimately contributing to decline and mortality.

Previous work has shown that at site specific scale, soil nutrient status between declining and healthy trees, differs, suggesting that changes in the soil microbial activity rates that mediate biogeochemical processes, may either contribute to, or result from, the progression of oak decline. Potential microbial activity can be measured using assays for specific enzymes, which act as catalysts in microbially mediated biogeochemical processes in soil such as recycling plant-available mineral nutrients; decomposition and stabilization of leaf and root litter-derived carbon. Thus, soil enzymes activities are suggested as good indicators of soil health and ecosystem health and function. When analysed in oak rhizosphere soils these indicators may be able to give early warning of or indicate susceptibility of a tree to oak decline.

A manipulated field experiment on mature sessile oak trees, with 18-month rain exclusion shelters to simulate drought and a partial ring-barking treatment to create nutrient stress to trees, was used to investigate the effects on potential microbial activity of these potential environmental drivers. Drought-induced changes in soil nutrient dynamics, reduced leaching and plant take-up increased nitrogen and other nutrient availability, making soil microbial activity more carbon limited. Nutrient stress increased enzyme vector angle indicating increased soil microbial phosphorus limitation supported by soil available phosphorus content. Foliar and roots physiological responses and their chemistry were investigated as well as a detailed study of oak root ectomycorrhiza communities. Soil health recovery following rewetting of the drought treatments was evaluated using repeated soil enzyme activity and soil chemistry analysis. These insights are improving our understanding of how soil biogeochemistry processes and feedbacks will affect oak decline in climate change.

GT 09 - 622 - O

SOIL BIOLOGY, SOIL HEALTH AND ECOSYSTEM SERVICES

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Soil health is a cornerstone of ecosystem resilience and sustainability, enabling soils to maintain or recover their capacity to support the increasing demands placed on ecosystems by human activities. This resilience is underpinned by critical soil functions which drive the delivery of vital soil-based ecosystem services. The soil functions commonly considered in soil health assessments are those supporting Primary Productivity and Biomass Production, Carbon and Climate Regulation, Water Regulation and Filtration, Cycling of Nutrients and Habitat Provision for Biodiversity. Soil health indicator selection heretofore has been widely debated, with diverse approaches and viewpoints on how best to capture the health of a given soil. This frequently results in indicator selection that is based on resource constraints or legacy data and does not consider the purpose or scale of monitoring, nor what functions are being considered. This chapter focuses on four essential soil functions (Nutrient Cycling, Water Regulation and Filtration, Carbon and Climate Regulation, and Habitat Provision for Biodiversity), each represented through comprehensive cognitive models that illustrate the key processes supporting these functions. While these processes can often be measured, this generally requires controlled laboratory conditions, limiting their applicability for monitoring. Therefore, where it is not feasible to measure the processes directly, indicator selection for soil health monitoring should be defined by the soil and landscape parameters that underpin or support the delivery of those processes.

A fundamental aspect of this discussion is the role of soil biodiversity in shaping and sustaining soil health. Soil biological actors do not merely respond to soil conditions but actively drive many of the key processes that define soil health. The interactions between soil biota and physicochemical parameters are a continuous cycle that underpin the many soil processes, thereby directly influencing the functionality of agricultural soils. While factors such as soil type, climate conditions, and topography set constraints on soil properties, soil health itself is largely determined by dynamic properties that can be influenced by management decisions, particularly through practices that enhance soil biodiversity and biological activity. Given this perspective, soil biodiversity should be viewed as a foundational layer that supports and regulates soil functions, reinforcing that biological properties are not merely a consequence of soil health but one of its primary determinants and therefore a cornerstone of ecosystem resilience.

The cognitive models presented in this chapter offer a structured way to integrate biodiversity into soil health assessments, alongside chemical, physical and environmental parameters, ensuring that biological indicators are given appropriate weight in evaluation frameworks.



GT 09 - 664 - O

POSITIONING SOIL HEALTH WITHIN THE FRAMEWORK OF SOIL SECURITY

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soil health and soil security are vital to the long-term sustainability of global soils. While soil health is a widely used concept, it often lacks standardization and tends to focus narrowly on human-centered outcomes, overlooking broader ecological functions. This study situates soil health within the broader soil security framework, which encompasses five dimensions: capacity, condition, capital, connectivity, and codification (McBratney et al., 2014), to provide a more integrated and actionable understanding. Recent work by Evangelista et al. (2024) has further emphasized that soil security has emerged as an existential challenge in itself, requiring strategic approaches that can be understood, quantified, and managed through these five dimensions.

Using a matrix approach, we examined how soil functions, ecosystem services, and threats intersect with the five dimensions of soil security. This approach aligns with recent frameworks that evaluate soil health in terms of its capacity to deliver multiple ecosystem services rather than through aggregate metrics (Ros et al., 2022). A global survey covering seven regions revealed significant regional variation. Europe scored highest in codification, while Asia lagged across most dimensions. The analysis identified common areas of agreement and regional clustering, highlighting where soil health is most actively addressed.

Findings indicate that soil health initiatives are most strongly aligned with the 'condition' dimension, especially in relation to key soil functions such as food production and carbon storage. By embedding soil health within the soil security framework, the concept gains clarity, measurability, and policy relevance. This integration supports recent work demonstrating the linkages between soil security and broader health frameworks, emphasizing the interconnected nature of soil, human, animal, and environmental health (Swan et al., 2024).

This integrated approach enhances our understanding of soil health's vital role and its relationship with ecosystem services and human well-being. It emphasizes that promoting soil security requires recognizing soil condition/health not as a standalone goal but as a foundational element of sustainable soil management.

ACKNOWLEDGEMENTS

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GT 09 - 680 - O

GRAZING PRESSURE MEETS FOREST INTEGRITY: SOIL RESPONSE TO WILD UNGULATES IN THE SASSO FRATINO UNESCO INTEGRAL OLD-GROWTH FOREST (ITALY)

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Grazing by wild ungulates, through browsing, trampling, uprooting, and defecation, alters plant-soil dynamics and affects ecosystem processes. Ungulate populations are increasing in many forests due to rewilding, land abandonment, reduction of predators, and improved habitat conditions. Overgrazing can impact various soil properties, such as water infiltration, nutrient cycling, and microbial activity. However, while a wide range of effects has been documented in agricultural systems (i.e., grasslands and integrated crop-livestock system), data are still limited for old-growth forests.

The Sasso Fratino Integral Nature Reserve (Province of Forlì, Italy), an old-growth forest included in the UNESCO World Heritage List, is home of five naturalized wild ungulate species occurring in high densities: red deer (Cervus elaphus L.), European fallow deer (Dama dama L.), roe deer (Capreolus capreolus L.), mouflon (Ovis orientalis musimon G.) and wild boar (Sus scrofa L.). These species have been found to reduce vegetation diversity and suppress forest seedling growth. The reserve lacks data on soil responses to grazing, prompting this study to evaluate the impact of ungulate overgrazing on soil physical, chemical, and biological properties by comparing grazed and (fenced) ungrazed plots.

Six sites dominated by Fagus sylvatica L. and Abies alba Mill. and located on Inceptisols derived from sandstone-marl sequences, were selected. Each site included a 6×6 m enclosure built in 2004. Three samples were collected inside and three outside the fences in 2024, and analyzed for soil bulk density (BD), water holding capacity (WHC), pH, electrical conductivity (EC), cation exchange capacity (CEC), soil organic matter (SOM), and total DNA yield as a measure of microbial biomass. We also quantified the microarthropod community in both the litter layer and the underlying mineral soil.

The results revealed no statistically significant difference in most chemical and physical soil properties between grazed and ungrazed areas, including SOM (14.16 ±0.85 vs 15.32 ±0.88 %dw, respectively), BD (1.65 ±0.07 vs 1.60 ±0.08 g cm-3, respectively), and WHC (37.27 ±1.81 vs 34.42 ±1.37 %dw, respectively). Also, DNA yield did not display any significant differences between the treatments (20.66 ±1.16 vs 20.79 ±1.64 μg g^{-1}). Microarthropod community showed slight variations unable to meaningfully discriminate between grazed and ungrazed areas (99.94±8.69 vs 82.94±9.17 in the litter layer and 107±22.37 vs 99±25.70 in the mineral soil).

In conclusion, ungulates do not appear to significantly impact soil properties in the Sasso Fratino forest. These findings may stem from the great forest's structural complexity and moderate grazing pressure, which, despite high animal densities, may buffer immediate impacts.



GT 09 - 685 - O

THE QUANTISLAKETEST APPROACH FOR MEASURING SOIL STRUCTURAL STABILITY: INSIGHTS FROM NINE YEARS OF APPLICATION AND RECENT DEVELOPMENT

GT 09. SOIL HEALTH / GT 05. SOIL HYDROLOGY & EROSION

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Soil structure is one of the cornerstones of soil fertility and the ecosystem services it provides. Rooted in soil biological activity and tightly linked to the carbon cycle, it plays a decisive role in water retention and movement through cultivated horizons. These properties have a direct impact on root development, crop health, and the overall productivity of agroecosystems. Conversely, soil structure is itself directly influenced by agricultural practices.

Intensive farming practices can significantly affect soil stability, leading to a reduction in organic matter content, a loss of biodiversity, and increased susceptibility to erosion. To evaluate the impact of these practices, soil scientists have long focused on structural stability and its measurement. Various methods exist to assess this key soil parameter, but they are often time-consuming, labour-intensive, and require multiple operations or chemical products.

Alongside laboratory-based methods, the Slake Test show the disintegration of a soil sample submerged in water. It has been used as a qualitative and visual tool to demonstrate the effects of conservation practices on soil health, particularly during field days and agricultural fairs.

In 2017, we quantified this pragmatic approach by developing a new measurement protocol: the QuantiSlakeTest (QST). QST is a low-tech method that continuously records the disintegration. Initial applications of QST in Belgian long-term field experiments validated the sensitivity and discriminative capacity of the developed indicator, and highlighted the advantages of the QST [1].

Since then, we have applied the QST under controlled conditions and in on-farm networks as part of collaborative research projects and with farmer associations. Following the publication of the first article, the method has gained growing interest from both the scientific community and agricultural advisory services. It is now being applied at three Belgian universities and two research centres in France and further developments are underway to support its dissemination across Europe.

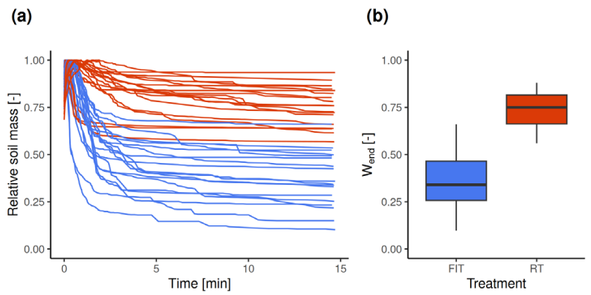
In this communication, we present findings from a retrospective application of the QST over the past nine years. The results highlight the beneficial effects of conservation practices on soil structural stability, both in controlled cropping system experiments and on real farms, across a range of temperate-region crops such as winter cereals and sugar beets, as well as practices related to cover crop management. Finally, we introduce recent developments in the new associated Python-based software which aims to support the wider dissemination of this open-source method among interested soil science laboratories and agricultural advisors.

ACKNOWLEDGEMENTS

Fund: CRA-W-Fond Moerman

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Slaking curves (a) and Relative weights at the end (b) show a significant lower soil structural stability where full inversion tillage (FIT) practices are applied in comparison to reduce tillage (RT) practices in a long term field experiment, Belgian loess belt arable farming systems.

GT 09 - 712 - O

DIGITALISING SOIL HEALTH INVESTMENT BY DATA INTEGRATION FROM BUSINESS MODELS. THE CASE STUDY OF TAMARGUILLO PARK (SEVILLE, SPAIN) IN THE FRAMEWORK OF THE NOVASOIL PROJECT

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Urban soils today face increasing challenges due to the growing demands for infrastructure, housing, and transportation driven by population growth and rural-to-urban migration. This leads to various anthropogenic threats to urban soils, such as compaction/sealing and contamination. In this regard, the EU-funded NOVASOIL project is focusing to highlight the benefits of investing in soil from the society and environmental perspective. In the context of urban soils, the aim of this work is to evaluate key parameters to evaluate the sustainability and promote the investment on urban green areas by scaling-up of the results. For that, the case study of Tamarguillo Park, located in Seville (Spain), is a urban park located between airport and the city. The primary threats are soil contamination, as well as residential development, traffic, and transportation planning.

A characterization of the identified landscape units within the case study has been conducted through the compilation of historical data (environmental and social) and a sampling campaign of physicochemical and biological variables. Furthermore, an analysis of key stakeholders and their activities was carried out to quantify the intangible benefits provided by the park. By analysing housing prices near different urban parks in Seville, a positive correlation is found when compared to the general price increase observed in areas further away from urban parks. Considering the park's area, the initial investment cost plus annual maintenance, and the generated benefits, an estimation is being made of the time and the minimum number of dwellings or activities required to recover the investment and ensure the park's sustainable management.

Specifically, in the case of Tamarguillo Park, the initial investment included a European grant for its creation, facilitating and promoting the environmental and social health of the area. For that, incentives and other mechanisms will be included in the scaling-up process.

ACKNOWLEDGEMENTS

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GT 09 - 740 - O

META-ANALYSIS ON SOIL ORGANIC CARBON AND CEREAL PRODUCTION IN ORGANIC FARMING SYSTEMS ACROSS EUROPE

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Organic farming may improve agroecosystems' resilience against external stressors, favour below-ground biodiversity, soil health, and increase soil water holding capacity. At the same time, organic farming systems are repeatedly reported to have lower average crop yields than conventional systems. To date, global meta-analyses on organic farming systems include a diverse range of crops, but none of them specifically focus on arable systems with cereal-based rotations. Further, they are not representative for specific European agro-environmental zones and often show weaknesses in the applied meta-analytical methodology.

This meta-analysis aimed at quantitatively summarizing existing knowledge and outcomes on soil organic carbon (SOC) in the topsoil (0-20/30 cm) and cereal production (i.e., yields and yield stability) in organic farming systems compared to conventional farming systems across Europe. The database consisted of 43 independent field studies on SOC and 50 field studies on cereal yields across 16 European countries, covering nine European agro-environmental zones. Cereal-based rotations were cultivated organically and conventionally on mineral soils, up to several decades. Yields for winter rye, winter and spring wheat, spring barley and spring oats were annually measured. SOC was measured as stock or concentration at the end of the experiments.

The overall effect of organic farming was a 5% increase of topsoil SOC (95% CI: 1% – 9%, n=43) compared to conventional systems. Pedoclimatic factors, such as mean annual precipitation and clay content had a profound impact on SOC response under organic farming (p=0.014). With increasing annual precipitation and clay content, SOC response to organic farming was increasing, and reached 20% in areas with clayey soils and annual precipitation of 700 mm. In addition, the response of SOC to organic farming showed some positive trend with increasing soil pH (p=0.059).

Overall, cereal yield in organic farming was about 30% lower compared to conventional farming systems. However, yield performance of organic systems varied statistically significantly across farming types (p=0.021): a 20% yield gap was observed in organic systems using animal-based fertilizers, while a 35% yield gap was shown in organic systems using only legumes or mixed green manure. Moreover, the yield gap decreased with increasing average annual temperature (p=0.002). Overall, the temporal yield variation of organic farming systems was about 50% larger than in conventional systems, which was not related to any pedoclimatic factors studied.

In conclusion, organic farming systems had a positive impact on SOC in the topsoil, compared to conventional systems. The magnitude of this influence mainly depended on pedoclimatic characteristics in Europe. In terms of cereal production, organic farming had lower yields and yield stability compared to conventional farming.

GT 09 - 756 - O

AGRIVOLTAIC PANEL SHADING ALTERS SOIL NUTRIENT DYNAMICS AND MICROBIAL COMMUNITIES

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Agrivoltaic systems, which integrate photovoltaic panels above cultivated fields, represent a promising land-use strategy to co-produce food and renewable energy, thereby mitigating land-use conflicts in the context of growing global population pressures. However, the impacts of such systems on soil biogeochemistry and microbiology remain insufficiently characterized. This study, conducted within the framework of the SUNRISE project, investigates the effects of agrivoltaic trackers with varying Ground Coverage Ratios (GCR—the proportion of ground shaded by panel arrays) on soil physicochemical and ionomic properties, as well as on the composition and diversity of soil microbial communities. Field experiments were conducted in a wheat-cultivated field using two configurations: standard (STV1, GCR = 13%) and extended (STV2, GCR = 41%) trackers, compared to a full-sun control (CI).

Soil chemical analyses revealed significant increases in organic carbon, total nitrogen, Olsen phosphorus, and exchangeable calcium, potassium, and magnesium under STV2 relative to the control. Ionomic profiling showed marked enrichment in elements including iron and manganese under STV1 compared to CI, with further significant increases under STV2. Amplicon sequencing of the 16S rRNA and ITS1 regions revealed a reduction in bacterial and fungal diversity (Shannon index) under STV2. Significant taxonomic shifts in microbial and fungal communities were also observed at both the phylum and genus levels compared to CI.

These findings suggest that the enhanced shading provided by STV2 altered key soil chemical properties, potentially reducing nutrient leaching and facilitating nutrient retention, while concurrently restructuring soil microbial assemblages. Although reduced microbial diversity was observed, the functional consequences of this shift require further investigation, particularly to determine whether functionally redundant or specialized taxa were affected.

Overall, the results underscore the central role of agrivoltaic design, specifically shading intensity and GCR, in shaping belowground processes with critical implications for soil health and the long-term agroecological sustainability of dual land-use energy–food systems.



GT 09 - 783 - O

MEASURING AND INTERPRETING SOIL AGGREGATE STABILITY AT SCALE VIA SLAKING IMAGE ANALYSIS

GT 09. SOIL HEALTH / GT 05. SOIL HYDROLOGY & EROSION

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Aggregate stability is an essential indicator linked to soil structure, erosion, water movement, habitat quality, and crop growth. Until recently, aggregate stability assessment was limited to qualitative in-field procedures and laborious, time-consuming lab methods. We present a rapid, low-cost, high-throughput method based on automated visual assessment of slaking that has been field tested on over 6,000 samples and is currently deployed by commercial laboratories. Intact aggregates are collected from the field, air-dried, and analyzed in triplicate. Aggregate stability is assessed by submerging 3 aggregates in water per petri dish and collecting images before and 10 minutes after submersion using digital cameras and automated timers. The areal expansion of aggregates is measured with automated image analysis. The materials needed to run this method are available as public standard operating procedures and open-source software, in the form of an updated Slakes smartphone app and SlakeItEasy R package. The North American Project to Evaluate Soil Health Measurements found that Slakes was responsive to cover crops and decreased tillage in paired treatments of long-term agricultural research experiments. Since then, Slakes has been measured as a part of six on-farm projects benchmarking soil health in sixteen MLRAs in the USA and one Level II Ecoregion in Canada. Results indicate soils managed with soil health practices (e.g. cover cropping, reduced tillage) often have significantly greater aggregate stability than soils under managements not employing the practices. Additionally, instances were documented where implementation of soil health management practices increased aggregate stability but not soil organic carbon. These on-farm benchmarking results, combined with findings from the North American Project to Evaluate Soil Health Measurements, demonstrate that Slakes is a frontrunner indicator of progress from soil health management practice adoption. Based on benchmarking results, regionally relevant interpretations can be provided for Slakes results within previously sampled regions. This represents an important step in improving access to aggregate stability measurement and interpretation for producers, crop advisors, and retailers.

GT 09 - 801 - O

CAN COVER CROPS INFLUENCE SOIL WATER REPELLENCY IN SOUTHERN UNITED STATES SOILS?

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Protecting and improving soil health has become a major goal for policymakers, conservationists, landowners, and farmers. In recent years, there has been a shift from conventional to more conservation-oriented management practices to help preserve soils and promote overall health. Among the conservation-oriented practices, cover cropping has gained popularity due to the benefits they provide which include reducing soil loss via runoff and erosion, improving soil structure, reducing weed pressure, and enhancing carbon sequestration. However, there is minimal information on how live cover crops and their residues influence the development of soil water repellency (SWR). SWR, a natural phenomenon that occurs in soils worldwide, can negatively affect soil hydrology, reduce cash crop quality and yields, and threaten food security and farmers' livelihoods. To address this knowledge gap and determine if cover crops have the potential to influence the development of SWR, a field experiment was conducted in the Southern Piedmont region of South Carolina, United States. Four cover crop species (cereal rye, crimson clover, radish, and red clover) were grown alongside a fallow treatment. Residue samples were collected from each treatment at the time of termination and four weeks after termination. The samples were then oven-dried, ground, and analyzed for water repellency using the water drop penetration time (WDPT) test. The WDPTs of the cover crop biomass at termination and four weeks after termination ranged from 49-4,174 and 8-2,627 seconds, respectively. WDPTs >5 seconds indicate the potential influence of cover crop residues on the development of SWR. Crimson clover residues collected at the time of termination generally exhibited the highest degree of water repellency. All cover crop biomass and residues exhibited water repellency, indicating that cover crops may influence the development of SWR over time when integrated into a cropping system rotation. Additionally, short-term effects on infiltration and aggregate stability were measured. Aggregate stability generally improved throughout the cover crop growing season, while infiltration rates showed no consistent pattern. These findings highlight the importance of cover crop species selection, as cover crops can influence soil health indicators and the potential development of SWR.

ACKNOWLEDGEMENTS

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GT 09 - 802 - O

SOILS4MED SOIL MONITORING SYSTEM: DEVELOPING AN OPTIMIZED APPROACH FOR CAPTURING THE SOIL AND LANDSCAPE VARIABILITY OF THE MEDITERRANEAN REGION

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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In the Mediterranean region (MR), there is an urgent need to improve the availability and accessibility of soil data and information, and to harmonize methodologies to develop harmonized soil monitoring systems. The limited use and quality of soil data and information pose a significant barrier to sustainable land management and developing and implementing policies to protect, restore, and enhance soil health. To address it, the "SOIL health monitoring and information systems FOR sustainable soil management in the MEDiterranean region" (SOILS4MED) PRIMA-funded project engaged a large platform of scientists, stakeholders, and final users in the co-design of scientifically sound, sustainable, and policy-relevant integrated soil health monitoring systems adapted to the specificities of the MR soils and environments. To achieve this goal, the project addressed the following research question: How do we measure soil health in MR? Shall we adapt its definition and indicators across different environmental and soil types/conditions?

To support the development of the monitoring system, SOILS4MED conducted i) a systematic analysis and comparison of the two monitoring protocols identified as reference for the project, the LUCAS Soil module [1] and SOILS4AFRICA [2,3,4] project's protocol and ii) a review of major methodological aspects addressed by ongoing operational soil monitoring systems, with a particular focus on those of the MR, making use also of the information gathered by the project.

The SOILS4MED monitoring protocol, which will be validated and implemented in the project study areas, is characterized by several key features. Litter will not be sampled, but if present, it will be described. In line with the SOILS4AFRICA project, the 0-20 cm soil depth layer will be adopted as the topsoil layer, and the 20-50 cm soil depth layer as the subsoil layer, both to be sampled and described. The samples are taken by depth layer, regardless of the number or types of horizons intercepted by sampling. SOILS4MED describes the observed layers/horizons, especially the topsoil, according to a selected set of World Reference Base (WRB 2022) descriptors.

ACKNOWLEDGEMENTS

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GT 09 - 808 - O

WHAT COUNTS AS ADOPTION? BETTER ACCOUNTING OF SOIL HEALTH MANAGEMENT PRACTICES

GT 09. SOIL HEALTH / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Rigid definitions of soil health, regenerative, conservation, or sustainable management practices can exclude farmers from a conversation and do not facilitate clear scientific communication around agronomic management and changes in soil functioning. Agronomic practices are often described categorically. For example, in row crop systems, tillage practice description falls under the categories of conventional tillage, conservation tillage, or no-till. Nonetheless, in practice, especially in commercial production systems, tillage and other practices are a continuum that is difficult to categorize across multiple years and crop rotations. Two regenerative farming systems may have very different expressions of soil health principles of living roots, soil armor, disturbance, and biodiversity. To express soil health practices as a continuum, we introduce simple soil health management indices that can be used in communication with both scientific and nonscientific stakeholders and provide more clarity of communication and inclusivity when talking about the adoption of soil health-improving practices. We show the possibilities created in scientific analyses and connecting with nonscientists by using this system.

GT 09 - 814 - O

PESTICIDE-CONTAMINATED SOILS: A TRIAD-BASED STRATEGY FOR SOIL HEALTH AND LAND RESTORATION

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Healthy soil is essential to ecosystems and human well-being, even though increasingly threatened by contamination, particularly from pesticides.

Recent analysis of over 5000 soil samples collected across Europe (2015-2022) reveals that both currently approved and long-banned pesticides are still commonly detected. Substances like p,p'-DDT and atrazine (banned for years) were found in 31% and 17% of soils, respectively. Even more striking is the widespread presence of approved pesticides such as boscalid (36%) and epoxiconazole (32%), along with persistent metabolites like aminomethylphosphonic acid (44%). Greece and Poland show stronger associations with banned pesticides. Findings raise concerns about the long-term impact of pesticide residues on soil health, cross-border pollution and the effectiveness of current regulatory frameworks[1].

To address contamination risks, we propose to update the TRIAD approach for ecological risk assessment (ERA) —traditionally based on chemical, ecotoxicological, and ecological lines of evidence. By integrating soil quality indicators and cutting-edge meta-omics tools, a deeper insight into contamination impact can be achieved. When combined with machine learning tools, ecological effects and ecosystem-level impacts of contamination can be predicted[2].

The TRIAD framework offers an accurate way to evaluate pesticide-contaminated sites. Most importantly, it aligns with the EU's goals for soil health and restoration, providing scientific foundation for sustainable and effective monitoring and remediation strategies. We aim to test and validate these approaches using pesticide-contaminated soils from national case studies in Portugal, within the scope of the ISLANDR project[3], which promotes risk-based land management and the integration of soil health into decision-making to achieve the Zero Pollution targets of the EU Green Deal.

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GT 09 - 830 - O

FRACTIONS OF SEQUESTERED SOIL CARBON IN ABANDONED AGGREGATE PITS “RESTORED” TO GRASSLANDS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Surface extraction of sand and gravel (aggregates) from suitable landscapes is necessary to provide road and building materials; however, the resulting degradation of the impacted area is significant. Once extraction ceases at an aggregate pit, the province of Ontario, Canada, mandates that a site be restored to a viable ecosystem. Unfortunately, restoration measures are often limited to regrading the land and application of a native seed spray, with negligible soil amendments. Thus, an ecosystem is left to initiate on barren crushed rock and sand, devoid of any measurable organic matter. This can lead to invasive plant dominance, reduced biodiversity, low carbon sequestration, and limited nutrient cycling. Not all soil organic matter is stored equally, with the fraction associated with fine silts and clays more protected and persistent than organic carbon present in the coarser soil fractions; however, the fractionation of soil organic carbon (SOC) in degraded landscapes such as aggregate pits has not yet been studied. This study presents SOC storage in abandoned sand and gravel pits restored to grasslands in temperate southern Ontario, Canada. Soil samples were collected from five restored aggregate pits varying in time since restoration (4 to 19 years) and parent material (sand, till, gravel), as well as an unrestored gravel pit abandoned for at least 30 years. Samples from the 0-5-, 5-10-, and in some cases 10-15- and 15-20-cm depths were collected from across each site for analysis. Soils were separated using standard sonification and wet sieving methods into free-particulate organic matter (fPOM), occluded POM (oPOM), coarse silt, and mineral associated-OM (MAOM) fractions and analyzed for carbon and nitrogen percentages, and 13-C and 15-N isotopic ratios. All sites were composed of predominantly coarse-grained material, ranging from 74 to 97 % > 2 mm. Bulk soil C ranged between 0.5 and 5 % and soil N between 0.04 and 0.6 % across the study sites and depths. While material collected in the fPOM stage consistently contained between 10 and 50 % organic carbon, the total mass of this fraction was low, representing between 3 and 16 % of the total SOC pool. The mineral-associated organic matter fraction (MAOM, the proportion linked to clay) ranged from a low of 11 % or total SOC in the site restored four years prior to sample collection (the youngest site) to a high of 49 % of SOC in the site restored 19 years prior to sampling (the oldest site). This trend of increasing time since restoration leading to increased SOC as MAOM should be treated with caution, however, as proportions between other fractions and the isotopic results confound interpretation. These results suggest a great range in SOC storage and turnover between ecosystem restoration projects, which may make generalizations of restoration as a means to increase the terrestrial carbon pool difficult.

GT 09 - 160 - F + P

LESSONS FROM 5 DECADES OF NATIONAL SOILS MONITORING IN GREAT BRITAIN

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The European Union has a long-term objective to achieve healthy soils by 2050 and with the European Council agreeing a provisional deal with the European Parliament on a framework for EU soil monitoring within the Soil Monitoring Law (SML). The first stage of this is the establishment of a soil monitoring framework to assess soil health throughout EU member states. Situated in NW Europe, the UK has extensive experience in large scale soil health monitoring over the last half century, through the UKCEH Countryside Survey across Great Britain. The successful implementation of this program for almost 5 decades has resulted in it underpinning the design of the three co-existing national soil monitoring programs in the devolved nations, in the form of the Environment and Rural Affairs Monitoring and Modelling Programme (ERAMMP) in Wales, The UKCEH Countryside Surveys of Northern Ireland and the England Ecosystem Survey (EES). As such, we discuss the principles underpinning this monitoring strategy, lessons learned from its implementation, and how the data collected from this program continues to be used to inform science and policy development, in the hope that it may usefully contribute to this wider EU effort. The UK monitoring program presented uses a stratified-random design, has matured in support of policy questions, and operates over space and time scales relevant to the SML. Key principles and lessons learnt include the balance between adopting a clear, question-based approach to set specific objectives and the importance of long-term continuity in methods. Having a robust statistical design that permits flexible sampling effort with shifting priorities has been key, along with selecting a core suite of indicators that can address key questions with use of robust and well-tested methodologies. The use of a stratified random sampling approach has proven both cost-effective and suitably flexible to support consistent reporting and flexible sampling effort, simultaneously. Common protocols are vital for future intercomparisons, but a full ecosystem approach that includes co-located soil and vegetation samples for interpreting a co-evolving system has proved hugely advantageous when it comes to understanding the drivers of change. This has facilitated the use of UK monitoring data in the development and training of statistical and process-based models, to understand and predict changes to natural resources for policy. At its core, long-term monitoring of soil condition has provided unique insights into the impacts of policy, management and climate on our soils at scale, and we believe will play an important role in successfully addressing the role of soils in the major societal challenges of our time, such as maintaining food production and addressing climate change and biodiversity loss.



GT 09 - 279 - F + P

SOIL QUALITY ASSESSMENT IN PARKS AND GARDENS OF VITORIA-GASTEIZ

GT 09. SOIL HEALTH / GT 02. SOIL PHYSICAL CHEMISTRY

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This study investigates the condition of soils and tree degradation across 16 parks and green spaces in the city of Vitoria-Gasteiz, where many tree species—including birch, maple, poplar, linden, and cedar—are exhibiting signs of decline. Symptoms include leaf wilting, premature defoliation, and increased vulnerability to pests and diseases, accompanied by rising mortality rates. The primary factors identified are soil compaction, declining soil fertility, and challenging climatic conditions, all of which limit root development and hinder the uptake of essential nutrients. This situation calls for a rigorous scientific approach to evaluate and enhance soil properties in these urban green areas.

The issues addressed by this study are critical for the sustainable management and conservation of the city's parks and gardens:

• Urban Ecosystem Preservation: urban trees provide essential ecosystem services such as air quality improvement, heat regulation, and biodiversity support. The degradation of tree health jeopardizes these vital functions.

• Soil Quality Assessment and Improvement: the study aims to characterize soils using biological, physical, and chemical indicators. These analyses allow for the identification of current edaphic limitations and the proposal of corrective measures to restore soil fertility.

• Environmental Risk Management: A deeper understanding of soil–plant interactions is necessary to anticipate and mitigate the effects of abiotic and biotic stressors on urban trees. The study will generate critical data to support proactive risk management.

• Optimization of Management Practices: Study outcomes will inform soil and irrigation management strategies, focusing efforts on high-risk areas and optimizing resource allocation.

• Long-Term Sustainability of Urban Green Spaces: By providing a solid scientific foundation for green space management, the study contributes to the long-term resilience and sustainability of urban parks, ensuring their continued provision of ecosystem services.

ACKNOWLEDGEMENTS

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GT 09 - 308 - F + P

SOIL HEALTH IN DIFFERENT EXPERIMENTAL FIELDS: THE APPLICATION OF THE SOIL QUALITY INDEX AS AN INTEGRATED TOOL FOR SOIL MONITORING.

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil quality determines the biological equilibrium and regulation of soil ecosystem services. Several chemical (pH, organic carbon, total nitrogen, available phosphorus), physical (texture, bulk density, water retention), and biological (microbial activity and biomass)[1] indicators are useful in determining soil quality. However, individual properties, the expression of specific soil processes, cannot reflect many reactions that determine soil functionality.

Complex indexes are the mathematical combination of different biochemical properties, and complex statistical procedures can describe the complexity of soil systems. The Soil Quality Index (SQI) aims to evaluate soil quality and functionality using individual soil properties[2] combined with a process that includes (i) indicator selection, (ii) scoring, and (iii) integration into the index.

This SQI has been applied in four agronomic trials located in Italy: TOMATO – comparison between organic and conventional management with tomato as a crop; VINEYARD – application of three organic-based fertilizers in a vineyard; CROP – four crop rotations are compared (continuous corn, continuous wheat, biennial rotation with corn-wheat, 9-year rotation with corn-wheat-alfalfa); CORN-WHEAT – a biennial rotation with manure and crop residues as fertilizers.

The SQI was determined for each experimental system considered and the minimum dataset consists of four to five parameters such as specific enzymatic activities, and carbon and nitrogen pools.

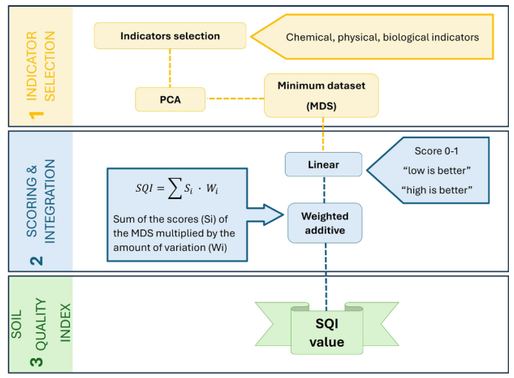
The highest SQI value (38.1) was measured in the trial CORN-WHEAT in correspondence to manure addition, while the lowest (7.9) corresponded to the control plot in the VINEYARD. The SQI showed coherent results within TOMATO, CROP, and CORN-WHEAT trials with values ranging from 14 to 38 and trends that reflect the effects of the different soil management on soil functionality. Significantly lower data (7.9÷13.5) were calculated in the VINEYARD. This result is probably due to the types of cultivation (yearly crops compared to orchards) suggesting that this should be a criterion to be considered if a ranking for the SQI values is defined. Indeed, within the trial VINEYARD, the results are coherent with the fertilization strategies showing a higher SQI in correspondence with the plots treated with composted matrices.

The SQI has the advantage of providing information based on biochemical parameters that reflect soil functionality and health; it is easy to comprehend also outside the scientific community as higher values correspond to better soil quality. However, no standard reference values exist and comparison with controls is needed for soil quality assessment. An effort to collect all the SQI data worldwide should be made to try to reach out reference values and thus generate an approach for soil quality evaluation based on its functionality.

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GT 09 - 346 - F + P

EFFECTS OF MINERAL NITROGEN FERTILIZATION ON SOIL HEALTH INDICATORS: A CASE STUDY FOR THE LONG-TERM BROADBALK EXPERIMENT

GT 09. SOIL HEALTH / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Mineral nitrogen fertilizers are currently essential to sustain global food production. Yet, their production and use are associated with environmental burdens: their production processes and application are estimated to account for 5% of global greenhouse gas emissions [2], their use is a also major source of anthropogenic N2O emissions [4] and loss to water contributes to eutrophication [3]. Sustainable alternatives that also secure food production are, therefore, urgently needed. Biostimulants are viewed as a potential tool to achieve sustainable agrobiologicals, as they may reduce mineral (nitrogen) fertilizers use while maintaining optimal crop production [1]. However, long-term field trials running for several years are needed to demonstrate the products' effectiveness and ability to maintain or improve soil health. A crucial aspect in these field trials is the selection of soil health indicators. Yet, there is still limited information on the suitability of soil health indicators for these field trials. This project aimed at screening suitable soil health indicators for field trials related to biostimulants that reduce mineral nitrogen fertilizer use. This study shows the effects of long-term mineral nitrogen fertilization on a wide range of soil health indicators, related to enzyme activities, protein content, mineralizable carbon content, as well as microbiome composition and functionality. These soil health indicators were analyzed on soil samples from the long-term Broadbalk experiment in the UK, containing treatments with or without the addition of mineral nitrogen fertilization in combination with organic fertilization, P+K+Mg or no other fertilizer. Additionally, this research shows how the effects of long-term nitrogen addition differ between treatments (either additional organic, inorganic or no nutrients) and how soil health indicators are correlated with other soil health indicators. These results will aid in the selection of soil health indicators for future field trials related to mineral nitrogen fertilizers.

ACKNOWLEDGEMENTS

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GT 09 - 713 - F + P

SPATIOTEMPORAL MONITORING OF CARBON DYNAMICS AND TRACE ELEMENTS MODELLING IN-SITU AND EARTH OBSERVATION DATA.

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The increasing need for sustainable land management and soil health monitoring calls for innovative approaches integrating in-situ and Earth Observation (EO) data. This study focuses on the spatiotemporal monitoring of carbon dynamics and trace element modeling within the long-term case study of the Guadiamar Green Corridor in Southern Spain. By leveraging high-resolution remote sensing datasets and field measurements, we analyze the interactions between carbon fluxes and soil trace elements over time, providing insights into ecosystem recovery and resilience in post-contamination landscapes.

Additionally, the research aligns with the goals of the MRV4SOC project, which aims to develop methodologies for Monitoring, Reporting and Verification for soil organic carbon in representative soil and land use in Europe. The findings contribute to bridging the gap between scientific research, technological innovation, and practical applications for sustainable land use and climate resilience

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GT 09 - 728 - F + P

IMPACTS OF REDUCED DITCH NETWORK MAINTENANCE ON ECOSYSTEM SERVICES OF PEATLAND FORESTS IN FINLAND

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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According to National Forest Inventory, approximately 1.1 Mha of drained peatland forests require ditch network maintenance (DNM) in Finland [1]. Ten years ago, the annual area of DNM extended to 70 000 ha but currently, the annual DNM area covers only 7000 ha [2]. This leads to gradual shallowing of ditches and rise of water table (WT) in peatland forests. While DNM can increase stand growth, it has adverse environmental impacts, such as increased soil carbon (C) emissions and exports of nitrogen (N) and phosphorus (P) to water bodies [3,4].

To study the impacts of ditch shallowing on ecosystem services, we applied Peatland Simulator SUSI [5,6] and analysed ecosystem C balances of average peatland forests in Finland using ditch depths of 0.3 m, 0.6 m and 0.9 m. Based on empirical studies [7], we assumed that the ditch depths changed from 0.9 m to 0.6 m, from 0.6 m to 0.4 m and from 0.3 m to 0.2 m during the 20-year simulation period. The study sites included drained peatland forest types from nutrient rich to nutrient poor, with main species as Scots pine (Pinus sylvestris (L.) Karst.) or Norway spruce (Picea abies L.). The simulations were conducted for different parts of Finland. The ecosystem C balances were analysed together with soil C balance, stand volume growth, N and P exports to water bodies, and WT.

The results showed that ditch shallowing can lead to multiple benefits for peatland forest ecosystem services. Ecosystem C sinks increased with ditch shallowing in most sites during the 20-year simulation period when the initial ditch depth was 0.6 m or 0.9 m. Additionally, stand volume growth increased in Southern locations when the initial ditch depth was deeper than 0.6 m. In all sites and ditch depths, N and P exports, and soil C emissions decreases. Overall, ditch shallowing can be an environmentally and economically viable peatland forest management option in most regions.

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GT 09 - 770 - F + P

SOIL HEALTH IN VINEYARDS: THE SENSITIVITY OF SOIL BIOLOGICAL INDICATORS TO MANAGEMENT PRACTICES AT QUINTA DO CASAL DA GRANJA, PORTUGAL

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Viticulture is deeply established in European culture and plays a vital role in the region's economy. Wine quality is determined by the interaction between edaphoclimatic conditions, the soil biota, including microbiota and soil fauna, all of which contribute to the wine-specific terroir of each region. To guarantee the sustainability of these soil biological components, it is essential to monitor the impact of viticulture practices on soil health. This study aims to validate the sensitivity of several biological indicators to integrated production practices on Quinta do Casal da Granja (Real Companhia Velha, Alijó, Portugal). A vineyard sampling plan was co-created with wine growers considering three management variables: 1) the intensity of phytosanitary protocols applied to two different grape varieties: Moscatel Galego (more sensitive to pressure from pathogens) and Arinto (less sensitive). A greater sensitivity of the variety refers to the two main diseases that affect the vine crop: downy mildew and powdery mildew; 2) the soil vegetation cover in the between-row space (spontaneous vs. sown) and, 3) the period since the last deep soil tillage in the between-row space which is directly related to the age of the vineyard (older vineyards vs. youngest vineyards). The study began with soil sampling for biological indicators and for physical and chemical characterisation. The effects of the management practices are being assessed with a soil microbial community analysis using soil enzymes (dehydrogenase, urease, CM-cellulase, arylsulfatase, acid phosphatase activities), nitrogen mineralisation, nitrification potential, and soil microbial community functional profiling using EcoPlate™ (Biolog). Additional indicators of soil biological activity include cellulose decomposition (assessed through the filter paper method) as an indicator of the decomposition of organic matter by microbial action and basal respiration measured with the OxiTop® system. Soil fauna is being assessed via pitfall traps and bait-lamina feeding activity test, earthworm's (Oligochaeta) abundance and biomass and nematodes functional groups. These biological indicators make it possible to distinguish plots under the different management practices. In addition, the diversity of herbaceous flora covering the between-row space is being monitored as an indicator of the dynamics of soil cover under different management practices.

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GT 09 - 23 - P

HEALTHY GARDENS OR HIDDEN HAZARDS: ANALYZING SOIL HEALTH IN SMALL-SCALE AGRICULTURE

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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In the face of the triple crises of climate change, pollution, and biodiversity loss, growing vegetables in small gardens offers a promising solution. Previous studies have shown that small areas often face greater anthropogenic impacts compared to large-scale farmland, which this research aimed to investigate. The study was conducted in northern Serbia, Vojvodina Province, within the southeastern Pannonian Basin. Agriculture dominates, with 80% of 1.6 million hectares used for farming, 91.1% being arable land. Soil samples were systematically collected from 4 × 4 km quadrants (0–30 cm depth), totaling 1,364 samples. The distribution of samples: 1,084 from arable land, 93 from forests, 83 from meadows and pastures, 38 from abandoned land, 35 from gardens, and 31 from orchards and vineyards —reflects the actual proportions of land use in Vojvodina. Analyses included pH, carbonate content, organic matter (Tyurin method), readily available P_2O_5 and K_2O (ammonium lactate extraction), pseudo-total (H2O2 + HNO3 digestion), and available (EDTA extraction) copper.

The soils were mostly slightly alkaline with 5–10% carbonates, reflecting the loess and chernozem dominance of the region. Forest soils had slightly lower pH and carbonates. Organic matter, represented by median values, was influenced by human activity, with arable soils at 3.1 ± 3.2%, far below the region's natural humus-rich potential (>5%) due to intensive farming. Gardens showed slightly higher organic matter (3.2 ± 1.2%) than orchards (2.5 ± 1.2%) but lower than forests (3.7 ± 1.6%).

Readily available K_2O was fairly uniform across land uses, with a median value around 20 mg/100g, except in gardens, where excessive fertilization elevated it to 44.5 ± 36.3 mg/100g. Readily available P_2O_5 exhibited significant variation: it was low in abandoned land, meadows, and forests (5–10 mg/100g), optimal in arable soils and orchards (15–20 mg/100g), and toxic in gardens (116 ± 146 mg/100g). Copper concentration was highest in gardens, with median pseudo-total copper at 34.0 ± 39.6 mg/kg and available copper at 13.8 ± 24.8 mg/kg due to copper-based fungicides. Other land uses had median copper levels below 30 mg/kg (pseudo-total) and 10 mg/kg (available), with orchards and vineyards showing the highest values.

These findings highlight the need for better education among small vegetable producers, as overuse of fertilizers and fungicides—often without soil analysis—threatens soil health. Sustainable practices are crucial to ensure the long-term productivity of small-scale gardens.

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GT 09 - 30 - P

IMPACT OF TILLAGE PRACTICES, CROP RESIDUE MANAGEMENT, AND INTERCROPPING ON LONG-TERM SOIL HEALTH AND SUSTAINABILITY

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The long-term impact of different tillage practices, crop residue management, and intercropping on soil health is crucial in the context of climate change and the need for sustainable agriculture. This study, conducted at Vytautas Magnus University's Experimental Station since 1999, explores the effects of these agricultural practices on soil organic matter (SOM) accumulation, soil carbon sequestration, and overall soil health.

The research compares different tillage techniques, including conventional deep ploughing, shallow ploughing, ploughless tillage, and no-tillage systems, with or without cover crops. Additionally, it examines the impact of crop residue management (removal vs. chopping and spreading) on soil organic carbon (SOC) stocks and CO_2 emissions. A Soil Quality Index (SQI) approach, combined with radar diagram analysis, was employed to evaluate the effects on soil physical, chemical, and biological properties.

The results indicate that reduced tillage and no-tillage systems, when combined with the retention of crop residues and the use of cover crops, significantly enhance soil health parameters. The most substantial increases in SOC stocks were observed in minimally disturbed soils, while no-tillage systems also contributed to a marked reduction in CO_2 emissions. These findings highlight the potential of conservation tillage practices to improve soil resilience, increase agricultural sustainability, and mitigate climate change impacts.

By integrating agroecological principles into soil and crop management strategies, farmers can enhance soil health, boost carbon sequestration, and reduce greenhouse gas emissions while maintaining productivity. This study contributes to the growing body of knowledge on sustainable agricultural practices and their role in ensuring food security in the face of climate change.

KEYWORDS

Soil health, Tillage practices, Crop residue management, Soil organic carbon, Climate change mitigation, Sustainable agriculture.

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GT 09 - 37 - P

AN IMPROVED METHOD FOR MEASURING PEATLAND SOIL OXIDASE ENZYME ACTIVITIES

GT 09. SOIL HEALTH / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Background

Peatlands are vital carbon (C) sinks, but drainage and drought lower the water table, shifting their net C balance and accelerating decomposition1. This enhances extracellular enzyme activity, which mediates soil organic C mineralisation and dissolved organic C (DOC) transformation. Soil oxidases, particularly phenol oxidase (PPO) and peroxidase (PO), are key in breaking down complex aromatic soil organic matter (SOM) like lignin. However, oxidases remain understudied compared to hydrolases2.

Traditional oxidase activity measurements use L-DOPA as a substrate and autoclaved soil samples as controls. However, L-DOPA may not be ideal for peatland conditions, with ABTS proposed as a more suitable alternative for improved reliability3. Additionally, autoclaved controls can lead to inconsistent results, necessitating an evaluation of ABTS-based assays and improved control setups to enhance reproducibility.

Approach

This study aimed to improve PPO and PO activity measurement by modifying the negative control setup and using ABTS as the substrate in drained and forest-to-bog restoration peatlands. Soil samples were collected from temporary plots across these treatments using a Russian peat corer at 15 cm depth. Samples were sieved, homogenised, and stored at 4°C to preserve enzymatic activity. Soil moisture content (SMC) and pH were also assessed to examine their influence on oxidase activity. The study compared autoclaved and non-autoclaved controls to evaluate their impact on assay accuracy.

Results

PPO and PO activities were significantly higher ($p < 0.05$) in non-autoclaved than autoclaved samples, demonstrating the influence of control choice. SMC varied significantly across peatland treatments. Peroxidase was the dominant enzyme, highlighting its key role in peatland C cycling.

Conclusion

The inclusion of both autoclaved and non-autoclaved controls provides a more reliable measure of oxidative potential in peatlands. These methodological improvements enhance the accuracy of oxidase assays, advancing peatland C cycling research.

KEYWORDS

ABTS, Autoclaved Samples, Carbon cycle, Climate change, Drained Peatland

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GT 09 - 40 - P

THE CONCEPT OF THE NATURAL FRAMEWORK - AS A SPATIAL PLANING TOOL FOR THE LOCATION OF SUSTAINABLE SOIL USE MEASURES AND SOC MANAGEMENT IN AGROECOSYSTEMS.

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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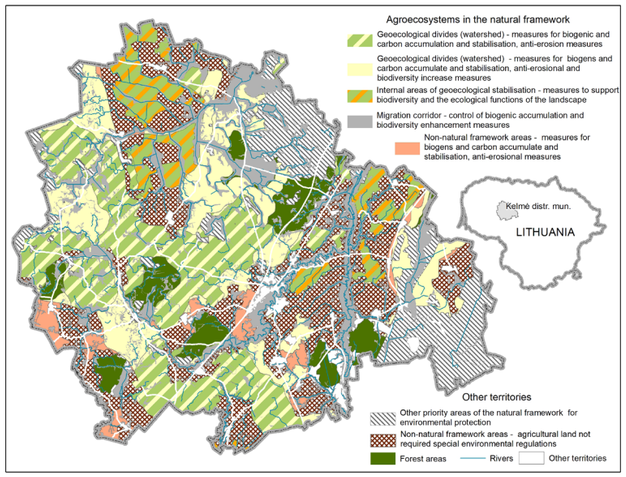
In the light of the global ecological and value crisis, a new integrated holistic approach to environmental development and sustainable land use is needed. The solutions for differentiating the intensity of soil use cannot be limited to agrotechnical, agrochemical or biological measures. Soil must not be approached through the elemental concept of the environment, but rather through the component and geosystemic paradigms of the landscape, thus creating the preconditions for the formulation and implementation of a regional policy on agroecosystem management. The concept of the natural framework, as applied to the sustainable functioning of the landscape and the quality of ecological services, can also be applied to the management of soil quality, health and intensity of agricultural use.

The natural framework consists of geoecological divides (uplands ridge tops), internal stabilisation areas (relatively flat surfaces) and migration corridors (valleys of rivers, lake systems and the drainage canals). It is a universal geosystemic concept that aims to ensure the quality and stability of the landscape as a geosystem, stabilising energy and material flows while creating reliable migration corridors for biodiversity. In agroecosystems, the application of this concept should be linked to recommendations for the differentiation of the type and intensity of agricultural practices (agrotechnical, agrochemical, cropping and perennial grassland et. al.). Some measures should be targeted at more ecologically sensitive agroecosystems or sites, while others should be targeted at less sensitive ones.

Soils in agricultural areas along geoecological divides are highly erodible and should therefore be subject to measures to reduce erosion risk, such as anti-erosion ploughing, no-till farming, perennial grasslands, pastures and livestock farming. This not only restores soil productivity, but also restores ecological compensation functions such as SOC accumulation, CO_2 sorption, nutrient accumulation and filtration properties.

Soils in the internal stabilisation areas are not at high risk of losing productivity, but some areas (local depressions) are less suitable for farming and may be subject to conversion to ecological land use in order to achieve economic reductions in CO_2 emissions from agriculture. This would not only increase the biodiversity of the landscape, but also create additional soil ecological functions by creating local nutrient accumulators and soil biodiversity hotspots.

Migration corridors in areas of intensive agroecosystems are the most frequent migratory routes for agricultural diffuse pollution, as well as for nutrients, and are therefore the last barrier to trapping them. Locating perennial grassland, agroforestry and organic farming on agricultural land in these areas would ensure the filtering and nutrient-accumulating properties of the soil, and use the moisture potential of these areas for the biological storage of CO_2.





GT 09 - 57 - P

HAZARD AND CARCINOGENIC RISK ASSESSMENT OF TRACE ELEMENTS IN URBAN SOILS OF A MIDDLE-SIZED CITY OF THE CENTRAL VALLEY OF CHILE

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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Recently, the increasing concentration of people in urban areas has arisen a concern to figure out the geochemistry of trace and toxic elements in urban soil. Surface soil has an important role in human exposure by ingestion, dermal contact, and inhalation. However, the studies on urban soils associated to trace and toxic elements are quite limited in South America. This work presents the first geochemical approach of urban soil in the city of Chillán, Chile. The levels of As, Cu, Sr and Zn were measured from topsoil (0-10 cm depth) samples (n =174) collected across a 500-m grid, chosen to be representative of the entire urban area within the city. The hazard index (HI) and carcinogenic risk (CR) were used to assess human health risk of trace and toxic elements. The mean concentrations for Cu, Zn, As and Sr were 71.8, 229.8, 11.2 and 234.6 µg/g dw, respectively. The values of HI for children and adults present a descending order of Cu >Sr >Zn > As. The CR values of As, Cu, Sr and Zn were within acceptable range for both age groups. This information is useful to implement plans to prevent future human exposure to toxic compounds in urban environments within changing sceneries.

KEYWORDS

Hazard risk · Trace metals · Soil · Urban soil · Carcinogenic risk · Soil contamination

GT 09 - 61 - P

EFFECTS OF SOIL MANAGEMENT ON ENZYME ACTIVITIES IN AGRICULTURAL FIELDS OF THE EBRO VALLEY (NE SPAIN)

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Agricultural soils perform essential functions besides food production. Consequently, improving soil quality is key to guarantee the sustainability of the agrosystems and mitigate the negative effects of climate change. Enzyme activities are considered reliable indicators of soil quality, as they react rapidly to changes in agricultural management practices. In this context, an evaluation of the long-term (> 10 years) of no-tillage on soil enzyme activities was carried out in field crops located in three municipalities of the Ebro Valley (NE Spain): Castejón del Puente, Pina de Ebro, and Sádaba. In the three locations, a non-tilled (NT) field was compared to a field in which conventional tillage (CT) was consistently carried out. In addition, in Castejón del Puente, two soil types with different gypsum contents were considered, while in Sádaba, a tilled treatment but with organic management was also considered. The fields compared in each municipality were adjacent to each other, thus minimizing differences in soil type, slope, etc. Each field was divided into four zones (replicates) and, in each of them, 4 to 6 soil samples were collected to obtain a composite sample per zone. Then, physico-chemical properties were determined using standard methods: texture, pH, field capacity, permanent wilting point, organic carbon, total nitrogen, available phosphorus, and cation exchange capacity (CEC). Moreover, biochemical properties including soil microbial biomass and enzyme activities (dehydrogenase, urease, alkaline phosphomonoesterase, and β-glucosidase) were determined. There was a trend to higher contents of organic carbon, total nitrogen, CEC and microbial biomass in NT fields, but significant differences with tilled fields were only detected in some locations. Enzyme activities were more sensitive to soil management, as most of them were higher under NT, except for urease (Table 1). However, there were some different behaviours among locations. Gathering data from all sites, some significant correlations were detected among enzyme activities and soil physico-chemical properties, for instance: urease vs. pH (r = 0.61), and alkaline phosphomonoesterase vs. available phosphorus (r = 0.59). In contrast, β-glucosidase was not related to any physico-chemical property. These results suggest that, apart from tillage, other agricultural practices are affecting the response of soil quality indicators; these aspects may include the destination and amounts of plant residues or the type of fertilizers used.

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Treatment	Urease	Alkalyne phosphomonoesterase	Dehydrogenase	β-Glucosidase
	µmol NH_3 g^{-1} h^{-1}	µmol p-nitrophenol g^{-1} h^{-1}	µmol INTF g^{-1} h^{-1}	µmol p-nitrophenol g^{-1} h^{-1}
Castejón del Puente				
NT – Chesa	1.54 ± 0.14 a	1.27 ± 0.06 a	0.069 ± 0.006 a	0.602 ± 0.021 a
CT – Chesa	3.04 ± 0.37 b	1.70 ± 0.17 b	0.141 ± 0.013 b	0.709 ± 0.063 ab
NT Valley	2.88 ± 0.35 b	1.69 ± 0.04 ab	0.134 ± 0.015 b	0.776 ± 0.033 b
Pina de Ebro				
NT	10.81 ± 0.61 b	2.50 ± 0.05 b	0.104 ± 0.015 b	0.774 ± 0.043 b
CT	4.92 ± 0.10 a	1.79 ± 0.05 a	0.061 ± 0.004 a	0.520 ± 0.029 a
Sádaba				
Organic	6.67 ± 0.15 a	1.87 ± 0.02 b	0.193 ± 0.010 b	0.722 ± 0.015 b
NT	6.88 ± 0.61 a	1.42 ± 0.01 a	0.132 ± 0.002 a	0.554 ± 0.031 a
CT	8.96 ± 0.48 b	1.56 ± 0.17 ab	0.154 ± 0.016 ab	0.656 ± 0.027 b
Analysis of variance				
Treatment	< 0.001	< 0.001	< 0.001	< 0.001
Location	< 0.001	< 0.001	0.090	< 0.001

Table 1. Mean (± standard errors) of four enzyme activities of agricultural soils from three locations in the Ebro Valley (NE Spain) subjected to different agricultural practices (NT = no tillage; CT = conventional tillage). Different letters in the column within each location indicate significant differences between agricultural practices according to the Tukey's test (? < 0.05).



GT 09 - 74 - P

APPLICATION OF CHEMICAL MASS BALANCE (CMB) AND POSITIVE MATRIX FACTORIZATION (PMF) MODELS TO DELINEATE BACKGROUND OF POTENTIALLY TOXIC ELEMENTS IN SOILS SURROUNDING INDUSTRIAL ZONES: A CASE STUDY OF THE KHUZESTAN STEEL COMPLEX, SW IRAN

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Introduction:

This study addresses this gap by quantifying As, Cd, Pb, Cr, Cu, Ni, Zn, and Co contamination levels while employing CMB and PMF models to identify pollution sources.

Material and Method:

Conducted in 2022, this investigation focused on soils surrounding the Khuzestan Steel Complex in southwestern Iran. A systematic sampling strategy divided the study area into 5×5 km grids, with adaptive spacing (2.5×2.5 km in high-risk zones, 10×10 km in peripheral areas). A collection of 56 soil samples occurred at grid intersections, with paired specimens taken from 0-5 cm (surface) and 5-20 cm (subsurface) depths. Source apportionment combined two receptor models, Positive Matrix Factorization PMF and CMB [1].

Results:

Co demonstrated the highest mean concentration in both sampling zones, reaching 13.02 mg kg-1 within the steel industry vicinity and 14.5 mg kg-1 in external samples. Conversely, Cd exhibited the lowest concentrations at 0.02 mg kg-1 (industrial zone) and 0.015 mg kg-1 (external areas). As, Cd, Cr, Cu, and Ni showed 18-32% higher mean levels within the steel complex boundaries compared to external samples. Pb and Zn concentrations paradoxically exceeded industrial zone levels by 12-15% in peripheral areas (Table 1).

In this study, based on the Q statistic, which evaluates the relationship between heavy metals and their sources, five sources were ultimately identified: the earth's crust (Factor 1), vehicles (Factor 2), the steel industry (Factor 3), biomass (Factor 4), and other sources (Factor 5).

Conclusion:

The results indicate that the steel industry has significantly contributed to soil contamination. According to the PMF and CMB methods, the steel industry factor, with a low standard deviation (1%), emerged as the primary contributor to PTES contamination in soil samples from the area. Pb, Cd, Cu, and Cr have contributed to changes in soil contamination [2]. Industrial activities, such as those in the steel industry in Ahvaz, are likely responsible for the high levels of Pb. Heavy transportation and traffic also contribute to elevated Pb levels. Zn and Cu originate from the erosion of alloys used in vehicles, other metal surfaces, and industrial processes. Co-contamination stems from the corrosion of metal parts in vehicles and the steel industry. The elevated levels of PTES in Ahvaz soil are likely linked to the presence of steel companies, the National Industrial Group of Iran, Steel Co., and power generation plants in and around Ahvaz.

KEYWORDS

Pollutants, Toxic Elements, Anthropogenic Activity

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Station	Location	HMs	N	Mean	Std. Deviation	Variance	Skewness	Kurtosis
1	In the area of Steel Co.	As	50	0.24	0.15	0.025	1.169	0.364
		Cd	50	0.02	0.01	0.000	3.092	9.330
		Co	50	13.02	5.60	31.424	0.181	-0.771
		Cr	50	0.78	0.28	0.084	0.575	-0.691
		Cu	50	0.60	0.25	0.065	0.518	-0.518
		Ni	**50**	**1.21**	**0.72**	**0.520**	**1.006**	**0.596**
		Pb	50	0.10	0.05	0.003	0.128	-0.265
		Zn	50	0.92	0.25	0.066	0.071	-0.542
2	Control; Outside the area of Steel Co.	As	6	0.10	0.06	0.004	.0678	-0.470
		Cd	6	0.01	0.001	0.000	-0.553	-2.143
		Co	6	14.51	6.09	37.108	-1.060	0.025
		Cr	6	0.77	0.30	0.091	1.827	3.464
		Cu	6	0.59	0.38	0.149	0.528	-1.676
		Ni	6	1.73	0.37	0.144	-0.861	-0.516
		Pb	6	0.18	0.08	0.007	0.652	1.269
		Zn	6	1.04	0.29	0.090	0.088	-0.635

Table 1. Descriptive statistics of PTES (mg kg-1) in soil samples around a steel Co. in southwestern Iran



GT 09 - 118 - P

EFFECTS OF GRAZING PRESSURE ON SOIL HEALTH IN SUBALPINE GRASSLANDS OF THE CENTRAL PYRENEES.

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Grasslands cover approximately half of the Central Pyrenees and have traditionally been used for extensive livestock grazing. Their high diversity results from the interaction between extreme climatic and edaphic conditions and a long history of grazing activity. In these systems, grazing pressure can significantly influence both pasture quality and soil health. To assess the ecological status of the soil, physical, chemical, and biological parameters related to key ecosystem functions were analyzed. These data will support the selection of a minimum set of indicators and the application of a soil quality index based on the proposal by Andrews et al. (2002).

The study was conducted in subalpine grasslands of the Central Pyrenees (Huesca, Spain), in two plots differing in grazing intensity: one with higher livestock activity (HGP) and another with lower pressure (LGP), which is more shrub-dominated. This difference is reflected in the vegetation cover, with a greater presence of woody strata in the LGP plot (26.5%) compared to the HGP plot (9.8%) (Figure 1). Soil samples were collected at two depths: 0–6 cm to determine bulk density and mesofauna diversity, and 0–20 cm for other physical, chemical, and biological analyses.

Preliminary results indicate that lower grazing pressure is associated with improvements in soil physical properties, including a 20% increase in structural stability and approximately a 70% increase in permanent wilting point in the low-pressure plot. In terms of chemical properties, total organic carbon content increased by 47%, and oxidizable organic carbon by 25%. Regarding biological properties, the mean residence time of carbon in basal soil respiration was 59% higher in the low-pressure plot. Additionally, microbial functional diversity, measured using the Shannon-Wiener index from Ecoplates, showed a significant 3% increase. In contrast, some variables such as mesofauna diversity, total glomalin content, and β-glucosidase activity did not show significant differences based on grazing intensity.

These findings highlight the influence of grazing management on soil quality, providing a valuable framework to support sustainable practices in extensive livestock systems in subalpine areas.

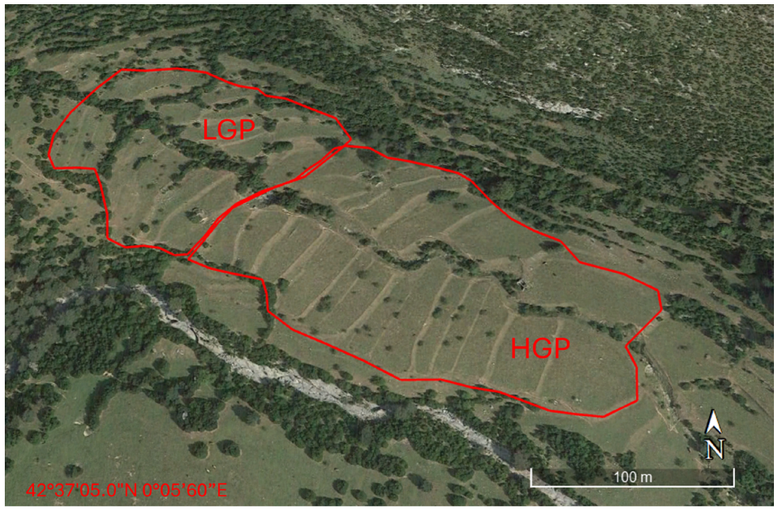


Figure 1. Location of the study area: High Grazing Pressure plot (HGP) and Low Grazing Pressure plot (LGP).

GT 09 - 123 - P

PARENT MATERIALS, TOPOGRAPHY AND LAND USE DRIVE THE SPATIAL VARIABILITY OF GEOCHEMICAL ELEMENTS AND SOIL FERTILITY IN KWARA STATE, NIGERIA.

GT 09. SOIL HEALTH / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Soils play a vital role in sustaining human populations by providing food, fibre, and fuel. As climate change intensifies, the need for sustainable soil management becomes increasingly critical. This study assessed soil nutrient status, geochemical elements, and fertility across Kwara State, Nigeria, using a uniform rigid grid sampling and geostatistical approaches. A total of 266 soil samples were collected and analysed using descriptive statistics, hierarchical clustering, and correlation analysis to identify key drivers of soil property variations and their interrelationships. The mean and median soil pH values were 6.63 and 6.8, respectively, indicating predominantly moderate pH conditions. High levels of soil organic carbon (SOC) were observed, with mean and median values of 2.19% and 2.21%, respectively. Correlation analysis highlighted soil texture, organic matter, and pH as critical factors influencing nutrient availability. Discriminant analysis revealed that soil parent material, land use, and topography were primarily distinguished by variations in soil particle size distribution, pH, and potassium (K^+) levels. The findings indicate that sandy soils are associated with higher pH, which enhances base cation availability but may limit certain micronutrients, whereas organic matter plays a crucial role in nutrient retention, and clay-rich soils exhibit a greater capacity to retain nitrogen (N). These insights provide a foundation for targeted soil fertility management strategies to enhance agricultural productivity and sustainability in the region.

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GT 09 - 144 - P

IMPACT OF COMBINED SOIL-CONSERVING TECHNOLOGIES ON SOIL STRUCTURE STABILITY

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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A variety of farming practices are currently being promoted in the agricultural landscape to limit soil degradation and support non-productive soil functions or soil health. They can therefore be understood as soil-conserving technologies. The aim of the research presented was to assess the effect of a combination of practices (specifically no-till system combined with nectar-bearing biobelts) on the stability of soil structure, as soil parameter influencing a range of physical and biological soil properties.

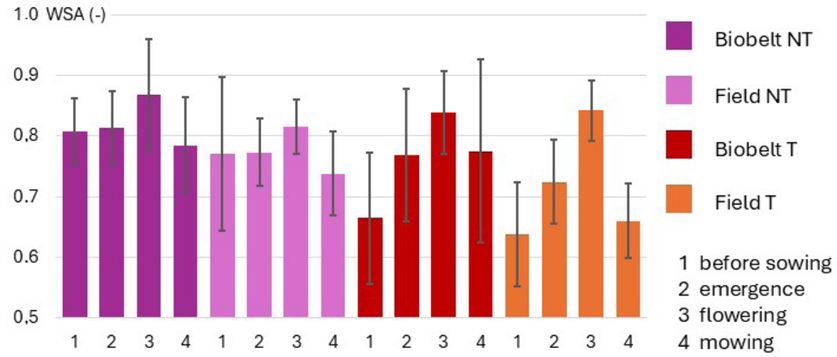
On the northern border of Prague, the capital of the Czech Republic, in the area covered by Chernozems on loess, an experiment was established in 2024 with 12 biobelts, 6 of which were established after tillage (T) and 6 on no-tillage (NT) fields. In addition to the comparison of soil properties between the biobelt and the field and the biobelt in NT and T variant, the variability of soil properties over time, i.e. from sowing of the biobelt to mowing, was also tested. The properties tested were soil aggregate stability (WSA), organic carbon content, pH and low molecular mass organic acid content (LMMOA).

As expected, the results confirmed a higher stability of soil structure (and even higher carbon content) in the no-till system compared to conventional tillage and a higher stability of aggregates in the biobelt compared to the neighbouring field in both tillage variants. The highest stability of soil structure was in the period of maximum vegetation development in the bio-belt. Interesting results were obtained when evaluating the combination of measures. Although the biobelts established in NT looked worse (lower height and density of vegetation), their effect was greater or rather caused a greater difference in WSA values between the field and the biobelt. In the NT mode, there was no intense fluctuation of WSA over time as in the T variant. The initial values of WSA before sowing were higher in the NT than in the T. In general, it can be said that the highest WSA value was achieved by the combination of NT and biobelt. Contrary to expectations, the effect of LMMOA (as an indicator of biological activity) on the stabilisation of soil structure was not confirmed. No significant trend in their content was found in relation to vegetation development, which is rather a consequence of the generally high variability of these acids in soils and their instability in the soil environment.

This is the first set of results from the first year after sowing biobelts. We therefore expect to see greater effects in the second or third year of their existence. However, in this case the combination of measures was able to achieve more benefits than the individual measures alone.

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GT 09 - 182 - P

SOIL REGENERATIVE MANAGEMENT PRACTICES ON SOIL CARBON STOCKS AND SOIL HEALTH IN POTATO PRODUCTION SYSTEMS

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil health degradation is a common issue under intensively cultivated coarse-textured soils, especially under potato-based systems. The present study, conducted in Prince Edward Island, compared four 3-yr potato rotation systems with and without manure (pen pack cow manure applied at 20 Mg ha-1 on a wet basis; i) (barley underseeded with red clover-red clover-potato (BRCP); ii) forage mixture (bromegrass, orchardgrass, common vetch)-forage regrowth-potato (FMP); iii) barley underseeded with annual ryegrass-pearl millet-potato (BPMP); iv) barley underseeded with annual ryegrass-sorghum sudan grass-potatoes (BSSP)). The trial was established in 2017, and the following parameters were analyzed six years later: carbon stock (0-15 cm depth; 15-30 cm depth), aggregate stability, soil respiration (flush of CO2 after rewetting air-dried soil), active carbon (permanganate oxidizable carbon), soil nitrate desorbed from anion exchange membranes over the winter (AEMN) following cover crop incorporation in fall 2023, mineral soil nitrogen (0-15 cm depth; 15-30 cm depth) in spring before cropping potatoes, and potato yield. Values were comparable among treatments for carbon stocks, soil respiration, and active carbon. Aggregate stability was higher with BPMP and BSSP than with FMP and BRCP, whereas AEMN and mineral N measured in spring 2024, before potatoes were higher with BRCP than with other treatments. Potato yield in 2024 ranged in the following order: BPMP≥FMP>BSSP≥ BRCP. There was a clear trend of manure increasing soil health, even if not statistically significant, with increases in carbon stock (0-30 cm depth) by 6%, in soil respiration by 13% and in active carbon by 11%. The results provide potato growers with regenerative soil management practices to enhance soil health and potato productivity.

GT 09 - 184 - P

INFLUENCE OF CROP BIODIVERSITY ON SOIL HEALTH AND VICE VERSA: EXPERIMENTING WITH CROP ASSOCIATIONS IN URBAN GARDENING AND MARKET GARDENING IN OCCITANIE

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The agroecological transition is necessary to promote overall health. However, sociotechnical and economic barriers are hampering its development, particularly for the widespread implementation of plant biodiversity (Tibi et al., 2022). Gaps in scientific knowledge exist, particularly regarding vegetable crop associations in France, in terms of agronomic (soil, yield, practices) and biological dimensions: plants, microbiota, etc. (Falgous et al., 2025). This is why, within the framework of the “Coculture” research project (ANR, INRAE and Toulouse University - Tiris), vegetable crop associations (APP) are being tested (2024-2027) with market gardeners and gardeners in (peri)urban areas, where agroecology and bio-densification are necessary due to the small areas available and regulations: Labbé law banning chemical pesticides (Dumat et al., 2025). These conditions make it possible to approach them in a transdisciplinary manner by integrating all the expertises, and then widely disseminating the knowledge produced to all practitioners and theoreticians. Rhizospheric and non-rhizospheric soils, in the case of monocultures and associated plants, from fifty gardens and market gardening farms are being studied (physicochemical fertility, microbiota, total and labile C and N, etc.) to explore the influence of soil health on the health of associated or monoculture plants, and vice versa.

The initial results of the “CoCulture” project, obtained as part of a thesis (Falgous L., 2025-2027), indicate that soil characteristics related to organic matter (total and labile C and N) vary greatly from one garden or market garden site to another, in relation to practices. These characteristics are likely to modify the microbiota of the rhizospheric soil and plants. In the case of the tomato-bean association successfully tested in 2024, and tested again in 2025, the results of the analyses to verify this effect will be presented, as well as the analyses of the correlations between all the characteristics of the soils (CEC, texture, pH, exchangeable inorganic nutrients and pollutants: NPK, Cu, Cd, Pb, Mn, Mg, etc.) and microbiota.

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GT 09 - 200 - P

SOIL HEALTH IN YOUR HANDS: VISUAL, RAPID, AND LOW-COST ASSESSMENT WITH BIOFUNCTOOL®

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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Biofunctool® is a low-tech, low-cost field kit designed to rapidly assess soil health by measuring key biological functions directly in the field. Unlike traditional laboratory-based methods that focus on static indicators like carbon or nitrogen stocks, Biofunctool® evaluates soil health through a functional lens, emphasizing the soil's capacity to perform essential ecological roles over time.

The kit comprises nine simple, rapid, and inexpensive tests that collectively assess three core soil functions: carbon transformation, nutrient cycling, and structure maintenance[1][2][4]. These indicators were carefully selected to be implementable in the field, capturing real-time soil dynamics and making the methodology accessible to a broad range of users, including non-experts. The results from these tests are integrated into a synthetic soil health index, which can be further broken down by function for targeted analysis.

One of Biofunctool®'s main strengths is its efficiency. The tests are designed to provide quick, actionable insights at a fraction of the cost and time required for laboratory analyses. This allows for immediate feedback and discussion with farmers and agricultural advisors, fostering direct engagement and shared understanding of soil health issues. The visual and straightforward nature of the results makes it easier for stakeholders to interpret data and make informed decisions about land management practices[1][6].

The tool's field-based approach is particularly valuable for understanding the local and specific impacts of agricultural practices on soil functioning. By enabling repeated, on-site measurements, Biofunctool® helps track the effects of different cropping systems, Tree plantations, or conservation techniques, supporting the agroecological transition at both local and broader scales. Its adaptability has been demonstrated across diverse agroecological and climatic contexts worldwide, from tropical to temperate regions (12 countries)

Furthermore, Biofunctool® serves as a bridge between scientific research and the agricultural community. Its ease of use and immediate, visual outputs promote dialogue among farmers, advisors, and researchers, facilitating the adoption of sustainable practices and the co-construction of knowledge on soil health[1][6]. As a practical, field-based tool, Biofunctool® is an important innovation for better understanding and managing the specific, local impacts of agricultural practices on soil health and ecosystem services

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GT 09 - 243 - P

EFFECTS ON SOIL QUALITY INDICATORS AT DIFFERENT DEPTHS IN TWO CROP AREAS: ANNUAL AND PERENNIAL

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The European Union Soil Strategy identifies the preservation and restoration of soil physical and biochemical health as one of its priorities, particularly in agroecosystems affected by decades of intensive agricultural practices. In this context, one of the most promoted approaches is the conversion of agricultural land (annual crop) into perennial plantations. While annual crops, such as maize, require frequent tillage, prolonged exposure to erosive effects, and intensive input use, perennial plantations can promote greater year-round soil cover, reducing erosion, improving water infiltration, and increasing soil organic carbon storage. In addition to environmental benefits, they offer economic returns [1].

Yost and Hartemink (2020) found that most soil health studies focus on surface layers up to 30 cm deep, with biological analyses typically conducted at an average depth of 20 cm. Deeper soil layers have gained growing attention due to their role in long-term carbon storage and their influence on bacterial communities, which are depth-dependent [2]. These studies are becoming essential tools for understanding sustainable land management strategies. Therefore, this study aimed to assess how soil depth and land use (annual vs. perennial cultivation) affect key soil quality indicators.

The study was conducted in a 10.7 hectare micro-watershed located in Galicia, northwestern Spain. In 2024, soil samples were collected from 72 georeferenced points at three depths: 0–30 cm, 30–60 cm, and 60–90 cm including a Eucalyptus spp. Perennial plantations and annual maize crops. The analysed indicators included: (a) enzymatic activities (urease, β-glucosidase, and phosphomonoesterase), (b) soil respiration, and (c) pH.

The results showed that enzymatic activities and soil respiration were directly affected by soil depth, decreasing with each analyzed layer but with some differences among land use.

ACKNOWLEDGEMENTS

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GT 09 - 246 - P

SOIL GEOCHEMICAL SURVEY OF ARMENIA: FROM REGIONAL TO NATIONAL SCALE

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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National-scale soil geochemical surveys are essential for generating data and information on soil chemical and mineralogical composition, determining soil texture, assessing various chemical, physical, and biological indicators, and developing data-driven strategies for soil management and sustainable food production. This study aims to present the efforts undertaken in the Republic of Armenia (RA) to carry out a national-scale soil survey and to provide insight into ongoing comprehensive geochemical investigations, using the Lori marz (region) as a case study. Over the past six years, regional-scale soil geochemical surveys have been conducted in 8 out of the 11 regions of the RA. Moreover, local-scale soil surveys of other cities of the country have also been conducted during the last two decades. Alongside these soil surveys, modern laboratory equipment and instruments-such as ICP-OES, XRF, and XRD-were purchased and installed at the Center for Ecological-Noosphere Studies (CENS). The results of these surveys are presented in the soil geochemical atlases of various regions, as well as in a number of scientific publications. Over the next 1-2 years, regional-scale soil geochemical surveys are planned for the two remaining regions. Following this, by incorporating soil samples from all regions - along with additional sampling in hard-to-access locations that were previously not covered - the first national-scale soil geochemical survey of Armenia can be completed and the first national soil geochemical atlas can be created.

Among the studied regions, the Lori region stands out due to its unique natural geochemical characteristics and its long history of mining activities. Currently, a large portion of the region's land (66% of its territory) is used for agricultural activities. However, detailed information on the soil's chemical and mineralogical composition, texture, and certain properties-such as soil organic matter content, pH, conductivity, and magnetic susceptibility-is still largely lacking. The preliminary results of the Lori's soil geochemical survey allow for the establishment of a unified geochemical dataset containing information on the abovementioned parameters. All of this information will be used for the geochemical characterization of the region's soils, the creation of thematic maps showing the spatial distribution of chemical elements and other parameters, and for planning and developing the soil vertical profile sampling strategy. Overall, the case study of the Lori region and the experience gained will be used in compiling the national soil geochemical atlas of RA, providing a scientific basis for initiating data-driven strategies for soil quality assessment and improved management of soil resources.

ACKNOWLEDGEMENTS

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GT 09 - 277 - P

RELATIONSHIPS AND PREDICTIVE POWER OF MANAGEMENT INDICES IN ASSESSING SOIL HEALTH IN CALIFORNIA VINEYARD SYSTEMS

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil health (SH) is increasingly recognised as vital to sustainable agricultural production, linking short-term yields to long-term ecosystem resilience. While the impacts of individual practices on SH are well documented, the broader management strategies they constitute - often classified using indices like 'organic' or 'regenerative' - remain evolving and warrant closer study. These indices classify farms based on management elements such as tillage, fertiliser application, and cover cropping. The widely-used organic index, for instance, primarily focuses on eliminating synthetic inputs to crops, whereas the newer regenerative matrix score emphasises producer flexibility - allowing the use of synthetic inputs when needed, while recognising the adoption of multiple, complementary practices that together enhance soil and ecosystem health. This study evaluates the relationships between these indices and key soil health (SH) indicators using generalised additive models (GAM). Results indicate that farms classified as organic or regenerative tend to exhibit stronger positive associations with SH variables compared to conventional farms. In particular, the regenerative matrix consistently demonstrated improved model performance and explanatory power across most SH indicators. To assess predictive accuracy, a spatially buffered leave-one-out cross-validation approach was applied to account for spatial structure often overlooked in ecological modelling. Echoing the GAM findings, regenerative scores generally produced lower predictive error rates. These findings support a growing distinction between organic and regenerative frameworks and suggest that the regenerative matrix may offer a more robust tool for evaluating and guiding SH-promoting practices.



GT 09 - 320 - P

PRELIMINARY EVALUATION OF POST-FIRE FOREST MANAGEMENT ON THE SOIL HEALTH OF BURNED CORK OAK FORESTS UNDER MEDITERRANEAN CONDITIONS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The current climate change trend, particularly in semi-arid regions, could result in more frequent and intense fires. The aim of post-fire management is to reduce the risk of land degradation and promote ecosystem recovery. However, conventional post-fire forest management cannot be adapted to certain edafoclimatic conditions. This study aimed to evaluate the combined effects of forest fires and subsequent forest management on the physiochemical and biological quality of soils in cork oak forests that were burned 18 years ago.

The study area was located in the Serra do Caldeirão (S Portugal), where the cork oak ecosystem is found on soils that are mainly classified as Leptosols. Several plots (706 m² per plot) that burned in 2004 were selected in this area. Some of these plots were managed as conventional forests with periodic brush clearing, while others were left unmanaged. In both scenarios (MP: managed, UMP: unmanaged), leaf litter was quantified and soil samples (n=6 per scenario; <5 cm depth) were collected and analysed for general physicochemical characteristics (mainly fertility-related) and dehydrogenase activity. This enzyme was used as a biological indicator of the functional diversity of the soil microbiome.

Areas under cork oak forest management had a higher density of trees and leaf litter amounts (t/ha, MP: 20.77, UM 7.07). In both scenarios, the Cistaceae family dominated the system, particularly Cistus ladanifer L., a species that commonly colonises Mediterranean ecosystems. Soils in both scenarios presented pH values of approximately 6 and low electrical conductivity (0.09–0.12 mS/m). The organic C fraction had the largest contribution to the total C content of the soils. Concentrations of organic C (g/kg, MP: 38.8, UMP: 40.0) and extractable P (≈3 mg/kg) were similar in both scenarios, but total N concentrations were almost double in the unmanaged plots (g/kg, MP: 1.9; UMP: 3.1), possibly due to the higher abundance of Fabaceae species. Higher litter biomass does not appear to have influenced soil organic C amounts. Despite similar amounts of organic C, the soils in the unmanaged plots can be considered more stable due to their lower content of labile C (g/kg, MP: 5.2, UMP: 3.2). Cation exchange capacity was also higher in soils from unmanaged plots (cmolc/kg, MP: 8.9; UMP: 37.1), which can be attributed to clays fraction. The dominant exchangeable cation was always Ca (cmolc/kg, MP: 7.1, UMP: 33.5), but the soils in the unmanaged plots showed a greater imbalance with the other exchangeable cations. The physicochemical characteristics of the soils, namely the differences in total N and labile C, did not affect the overall activity of the microbial community (63.6–73.6 µg TPF g-1 16 h-1).

In general, conventional forest management seems to have contributed to changes in soil quality, reducing soil fertility, in burned areas.

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GT 09 - 333 - P

ECOFARMERS PROJECT: SOIL MULTIFUNCTIONALITY AS A CRITERION FOR THE SELECTION OF INNOVATIVE STRATEGIES TO BUILD CLIMATE RESILIENCE IN MEDITERRANEAN AGRICULTURE AND FORESTRY

GT 09. SOIL HEALTH / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The Mediterranean region is undergoing fast climate change, with harsh and prolonged droughts and increasing rates of extreme events such as heatwaves and wildfires. The climatic pressures, along with farm abandonment and the progressive forest expansion over farm land areas, are modifying rural landscapes and decreasing the resilience of agriculture and forest. Understanding these conditions and the development of new, science-based management strategies are vital to maintaining, or improving, ecosystem function in these changing conditions.

The ECOFARMERS project is a research project supported by the Spanish Ministry of Science and Innovation (MICINN) and the Spanish State Research Agency (AEI), directed by the UAB-CREAF and the UB. It aims to assess innovative methods and products for the management of agricultural and forestry operations under increasingly climate-stressed Mediterranean conditions.

The project compares innovative management approaches with conventional across seven different scenarios in Catalonia: four agricultural (testing new types of fertilizers, biochar application, varying tillage regimes, and the use of sewage sludge versus mineral fertilization), two forestry (a chronosequence of afforestation and a scenario involving thinning and controlled burning), and one focused on restoring degraded areas. The different treatments in each scenario were compared with their corresponding conventional treatment using the innovative concept of ecosystem multifunctionality. For this purpose, various soil properties were used to quantify five ecosystem services: carbon retention capacity, biodiversity support, greenhouse gases mitigation, nutrient status maintenance, and primary production. Then, these indicators were integrated into a multifunctionality index to determine which treatment was most effective in each scenario.

The use of multifunctionality allows the identification of ‘win-win’ scenarios, that is management practices simultaneously enhancing multiple ecosystem services, therefore promoting sustainable agricultural and forestry that benefit both the environment and society.



GT 09 - 365 - P

SOIL QUALITY RESPONSE TO CULTIVATED AND INERT COVERS IN MEDITERRANEAN VINEYARDS: PRELIMINARY EVIDENCE FROM TWO COMMERCIAL SITES IN NORTHEASTERN SPAIN

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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Vineyards are a major land use in Mediterranean regions, often located in landscapes vulnerable to climate change and soil degradation. Spain, France and Italy together account for three-quarters (74.9 %) of the area under vines in the EU and about two-fifths (38.7 %) of vineyard holdings in 2020 (EUROSTAT, 2025). Improving vineyard soil management through cultivated and inert covers offers potential for enhancing soil fertility and resilience, while contributing to climate mitigation via increased organic carbon sequestration.

This study evaluates the effects of different inter-row soil cover strategies on soil physicochemical properties in two commercial vineyards located in northeast Spain. At the first one, two types of cultivated crops were evaluated: a legume-winter cereal mixture and a legume-only cover, both established in 2017. These were compared with a new plantation established in 2025 managed with a legume-winter cereal cover. At the second one, inert soil covers using wood shavings applied in 2021, 2024, and 2025 were assessed against respective control plots (bare soil). An initial soil sampling was conducted at 30cm depth, and key physicochemical parameters were analysed (pH, electrical conductivity, soil organic matter, oxidable carbon, total carbon, total and nitrates nitrogen, total and exchangeable potassium, total and soluble phosphorus, total copper, total zinc, texture, water holding capacity, permanent wilting point). Preliminary results from a non-parametric ANOVA (Kruskal-Wallis test) and post-hoc analysis (Dunn test with Bonferroni adjustment) indicated not statistically significant differences between treatments (a=0.5). However, consistent trends were observed: plots with longer-established soil covers showed higher levels of soil organic matter, oxidable carbon, total carbon, total nitrogen, potassium exchangeable, suggesting a progressive improvement of soil quality parameters over time. Future work includes the application of the Roth-C model, adapter for Mediterranean conditions (Farina et al., 2013) to simulate long-term changes in soil organic carbon dynamics under different management scenarios, supported by continued field monitoring.

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GT 09 - 421 - P

HIDDEN HARM: MICROPLASTICS IN SOIL ALTER BUCKWHEAT DEVELOPMENT AND SOIL HEALTH

GT 09. SOIL HEALTH / GT 02. SOIL PHYSICAL CHEMISTRY

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Microplastic pollution in soil is an emerging environmental concern, with growing evidence that tiny plastic particles are accumulating in agricultural land through sources like wastewater, compost, and degraded plastic mulch. Unlike in marine environments, the impact of microplastics in soil is still poorly understood. Early studies suggest they may alter soil structure, water retention, and microbial communities, potentially affecting plant growth and health. However, effects on crops—such as nutrient uptake, remain largely unknown, highlighting the urgent need for further research in this overlooked area of pollution.

This study investigates the short-term effects of polypropylene (PP) and polyethylene (PE) microplastics on soil pH and the physiological responses of buckwheat (Fagopyrum esculentum) grown in Endocalcari-Epihypogleyic Cambisol soil. Microplastics were applied at concentrations of 0.05%, 0.1%, 0.3%, and 0.5% by weight. Results showed that both PP and PE significantly increased soil pH in a dose-dependent manner, likely due to interactions with soil calcium carbonate and microbial activity. However, no significant changes were observed in total soil carbon or nitrogen. Buckwheat exhibited varied physiological responses depending on the type and concentration of microplastic. Low PP levels enhanced shoot and root growth, while higher concentrations led to reduced leaf number and biomass. PE exposure negatively affected root development and biomass across concentrations, though some recovery was observed at higher levels. These findings indicate that even short-term exposure to microplastics can alter soil chemistry and plant growth, underscoring potential risks to crop productivity and soil health in plastic-contaminated agricultural systems.



GT 09 - 467 - P

LIVESTOCK MANAGEMENT AND ORGANIC AMENDMENTS SHAPE SOIL BACTERIAL COMMUNITIES AND DRIVES ECOSYSTEM FUNCTIONALITY IN MEDITERRANEAN AGROECOSYSTEMS

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Livestock diversity and management practices are recognized as key modulators of ecosystem functioning and stability; however, their influence on soil bacterial communities—key drivers of biogeochemical processes—remains underexplored. In this study, investigates the influence of distinct grazing regimes (ovine, equine, and grazing exclusion) on the structure and functional responses of soil bacterial communities, particularly following organic amendment addition. Initially, bacterial community evenness did not differ significantly among livestock areas, suggesting a comparable baseline structure. However, following compost addition, microbial communities responded in divergent ways depending on the grazing regime, reflecting the legacy effects of livestock management on microbial resilience and plasticity. Before compost addition, soil bacterial communities were similar at the phylum level across all livestock areas, dominated by Actinobacteriota, Proteobacteria, Acidobacteria, Chloroflexi, Firmicutes, and Bacteroidota. However, at the family level, notable differences emerged, particularly between equine and livestock-exclusion plots, where Rhodobacteraceae and Comamonadaceae were significantly reduced. After compost application, bacterial community composition shifted markedly, with Lentimicrobiaceae increasing across all treatments, while Paludibacteraceae, Comamonadaceae, and Clostridiaceae were selectively enriched in sheep-grazed and exclusion soils. The enrichment of bacterial families such as Lentimicrobiaceae, Paludibacteraceae, Comamonadaceae, and Clostridiaceae after compost addition suggests enhanced microbial processing of organic matter, particularly through fermentation, denitrification, and cellulose degradation. Additionally, certain bacterial taxa were downregulated, but only in these two areas, indicating that compost effects were strongly modulated by prior livestock management. Our results underline the importance of considering microbial community dynamics in land management strategies, as they can mediate the ecosystem's capacity to respond to external inputs and contribute to long-term sustainability in agroecosystems.

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GT 09 - 478 - P

POTENTIAL SHIFTS IN PROPAGATION OF BACTERIAL CADMIUM RESISTANCE GENES IN CADMIUM CONTAMINATED SOILS UND FUTURE CLIMATIC CONDITIONS

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Between 14 - 17% of agricultural soils globally are contaminated with harmful metals such as Cd (1). Of particular concern is the mobile metal pool, available for microbe and plant uptake, potentially posing threats to soil health (2, 3). "Soil health" describes the ability of soil to provide a functional ecosystem sustaining microorganisms, plants, animals, and humans (4). Under future climatic conditions — simulated by +4°C and +300 ppm CO2 following the Shared Socioeconomic Pathway SSP2-4.5 scenario (5) — the mobility of Cd increases (2, 3). Consequently, crop safety might be threatened by Cd enriching in crops (3).

Bacterial metal resistance genes may play a vital role in maintaining soil health, especially regarding plant growth promotion services (3, 4). It is known that the combined stressors of climate change and Cd contamination shift microbiome structure and activity (2), but whether and to what extent climate-induced increases in Cd mobility propagate bacterial Cd resistance genes remains unknown. Additionally, it is unclear if plants tend to enrich Cd-resistant bacteria in their rhizosphere under future climatic conditions to sustain plant growth promotion under increased Cd mobility.

To understand the combined stressors of climate change and soil Cd contamination on bacterial metal resistance genes, we quantified the abundance of a bacterial Cd resistance gene in soils exposed to either today's or future climatic conditions using soil samples from Drabesch et al. (2024) (2). To further elucidate whether plants enrich a Cd-resistant microbiome in their rhizosphere to maintain beneficial plant growth promotion in Cd-burdened soils under future conditions, we obtained bulk and rhizosphere soils from Pienkowska et al. (submitted) (3). Quantitative PCR was utilized to quantify the gene czcA, the inner part of a Cd/Co/Zn efflux pump, according to protocols adapted from Roosa et al. (2014) (6).

In times of the triple planetary crisis — climate change, pollution, biodiversity loss — maintaining soil health is extremely important. The propagation of bacterial Cd resistance genes may help the soil microbiome to adapt to an enhanced Cd mobility under future climatic conditions and thus maintain vital soil functions like plant growth promotion.

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GT 09 - 482 - P

EFFECTS OF FULL SEASON COVER CROPS WITH AND WITHOUT MANURE ON SOIL HEALTH AND POTATO YIELD RESPONSES

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil health degradation is common issues under intensively cultivated coarse-textured soils especially under potato-based systems. The present study conducted in Prince Edward Island compared four 3-yr potato rotation systems with and without manure (pen pack cow manure applied at 20 Mg ha-1 on wet basis; i) (barley underseeded with red clover-red clover-potato(BRCP);ii) forage mixture (bromegrass, orchardgrass, common vetch)- forage regrowth-potato (FMP);iii) barley underseeded with annual ryegrass- pearl millet-potato (BPMP); iv) barley underseeded with annual ryegrass- sorghum sudan grass-potatoes (BSSP)). The trial was established in 2017 and the following parameters were analyzed six years later: carbon stock (0-15 cm depth; 15-30 cm depth), aggregate stability, soil respiration (flush of CO2 after rewetting air-dried soil), active carbon (permanganate oxidizable carbon), soil nitrate desorbed from anion exchange membranes over the winter (AEMN) following cover crops incorporation in fall 2023, mineral soil nitrogen (0-15 cm depth; 15-30 cm depth) in spring before cropping potatoes, potato yield. Values were comparable among treatments for carbon stocks, soil respiration and active carbon. Aggregate stability was higher with BPMP and BSSP than FMP and BRCP, whereas AEMN and mineral N measured in spring 2024 before potatoes were higher with BRCP than with other treatments. Potato yield in 2024 ranged in the following order: BPMP≥FMP>BSSP≥ BRCP. There was a clear trend of manure increasing soil health even if not statically significant with increases in carbon stock (0-30 cm depth) by 6%, in soil respiration by 13% and in active carbon by 11%. The results provide potato growers with regenerative soil management practices to enhance soil health and potato productivity.

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GT 09 - 484 - P

EFFECT OF DIFFERENT COVER CROPS ON SOIL ORGANIC CARBON FRACTIONS IN MEDITERRANEAN VINEYARDS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Carbon farming (CF) practices aim to enhance soil organic carbon (SOC) level to contribute to climate change mitigation. In vineyards, among the recommended CF practices - such as reducing tillage, organic fertilisation, optimizing irrigation - the use of cover crops (CC), is becoming increasingly widespread due to their ability to improve soil SOC levels and enhance overall ecosystem quality. This study was conducted in vineyards across Northern and Central Italy, where CC were applied either in every second row (Central Italy) or in all rows (Northern Italy). The impact of CC on SOC and its fractions was evaluated as a CF strategy by comparing CC-covered rows with adjacent rows without CC within the same vineyards, or, in Northern Italy, with adjacent bare soil. Specifically, SOC concentrations were assessed in different soil fractions: non-protected (250–2000 µm), physically protected (53–250 µm), and chemically protected (<53 µm), all of which are stable in water (water-stable aggregates - WSA). The results reveal that vineyard management incorporating CC exhibits higher SOC concentrations compared to those without CC. Consistent with the principles of CF, the findings indicate that maintaining cover crops in vineyards contributes to an increase in protected soil organic carbon (SOC) stocks. Therefore, vineyard management incorporating CC increased SOC in soil samples ranging from 12 to 29% and from 5 to 31% for the physically and chemically protected fractions respectively, as compared to vineyards without CC.



GT 09 - 493 - P

INDICATORS OF SOIL IMPROVEMENT: EVALUATING REGENERATIVE PRACTICES WITH LABILE AND STABLE CARBON POOLS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The global degradation of arable land, primarily driven by the decline of soil organic matter (SOM), remains a major concern. SOM plays a key role in maintaining soil functions and directly influences soil quality and health. This study aimed to evaluate soil regenerative management practices that enhance essential soil functions and to compare their effectiveness. We prioritized selecting approaches that allow effective monitoring of changes during soil management. Over a three-year period, we implemented core techniques, including minimum tillage and the application of natural minerals to improve soil physical properties, as well as cover cropping and mulching to increase SOM content. We assessed a range of chemical soil properties, such as Total Organic Carbon (TOC), labile carbon fractions (Permanganate Oxidizable Carbon – POXC, Dissolved Organic Carbon – DOC, NaOH-soluble fulvic acids), easily extractable glomalin-related soil protein (EE-GRSP), and plant productivity. Our results showed that minimum tillage had a significant time-dependent effect, leading to a 17.58% increase in surface soil TOC, a 40.85% increase in NaOH-soluble humic acids, and a 77.75% rise in POXC over the three years. Mulch and cover crop treatments also contributed positively to specific carbon fractions and crop yields. Different indicators varied in their suitability for detecting changes: labile carbon forms like DOC and POXC were more effective for short-term monitoring, while TOC, EE-GRSP, and NaOH-soluble humic substances proved better for long-term assessment. These findings offer valuable guidance for improving soil health through sustainable management practices. The selection of SOM trait indicators that detect short- and long-term changes in soil quality can be an important part of soil conservation monitoring systems.

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GT 09 - 497 - P

PERSPECTIVES ON SOIL HEALTH FROM EUROPEAN FOREST SECTOR STAKEHOLDERS

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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Currently, the understanding how forest stakeholders across Europe perceive soil health is not deeply studied. Therefore, the overall aim of this study was to explore how soil health is understood from perspectives of European forest sector stakeholders. The specific aims were to i) study soil health challenges identified by stakeholders, ii) importance of soil functions and soil health objectives connected to those and, iii) stakeholder needs and tools for soil health enhancement.

To study how European forest sector stakeholder understand soil health and related challenges, 7 semi-structured stakeholder workshops across Europe were organized in 2023 and 2024. These workshops were connected to forest Case Study Sites of Benchmarks project where forest soil health and related soil health indicators in relation to various forest management practices are studied. Workshops consisted of three parts: i) soil health challenges ii) soil functions and, iii) needs and support possibilities among stakeholders. The workshops engaged the participants in a dynamic interactive environment to support collaboration between and across stakeholder groups in the different case study regions.

We analyzed the data through a series of steps. First, we translated the responses, originally collected in various local languages, into English. Then, we organized these responses into four databases that held information from the three activities and the demographic data. These databases allowed us to group and compare the data by region, type of activity and stakeholder group. Using this structured data, we generated statistics, analyzed the text, created visual charts, and used tools based on artificial intelligence to ask specific questions for deeper insights.

According to preliminary results, common challenges related to forest soils are climate change, public awareness, economical pressures, biodiversity loss and erosion. The five most important soil health objectives were to increase organic matter and humus build-up, prevent soil compaction and erosion, enhance biodiversity and ecosystem services, water management and conservation, and nutrient cycling and soil fertility.

Knowledge compiled in this study can be utilized to inform future soil health monitoring frameworks and policies. In addition, the results can be used to strengthen synergies and create quality relationships for the enhancement of soil health within and beyond individual case studies.

ACKNOWLEDGEMENTS

We are grateful for all Case Study leaders of Benchmarks project for organizing stakeholder workshops and reporting the results.



GT 09 - 504 - P

SOIL RESILIENCE TO DEGRADATION UNDER THE EFFECTS OF GLOBAL CHANGE IN POLAND BY 2050

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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In Poland, approximately 62,000 hectares of soil are degraded due to soil threats (GUS, 2016). The spatial distribution and intensity of these threats evolve over time as a result of climate and land use changes. The main objective of this study was to evaluate the potential co-occurrence of SOC loss, erosion, compaction, and soil water retention, in order to identify areas susceptible to degradation, resilience, and recovery in Poland by 2050 under land use change and an extreme climate change scenario (SSP5-8.5), representing a high-emission pathway. Our findings, for the first time in Poland, demonstrate the co-occurrence of soil threats and reduced soil water retention by 2050. We estimate that by 2050, 47% of Polish soils will face some level of degradation, primarily due to compaction, erosion, SOC loss, and reduced soil water retention. The most affected areas would be in the north, northeast, centre, and the Carpathians region. The soil degradation index classified 31% of soils as low degradation, 10% as moderate, 2% as high, and 0.1% as very high degradation. Conversely, the resilience index shows that 29% of soils will not be affected by increased degradation, with 0.2% showing significant recovery (from three soil threats), 13% recovering from two threats, and 16% remaining stable, showing no change. The presented approach enables the identification of hotspots where soil degradation is likely to occur due to climate and land use changes, as well as areas demonstrating soil resilience. As such, this method offers a valuable tool to support the objectives of the European Green Deal and the EU Soil Strategy for 2050.

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GT 09 - 510 - P

SOIL HEALTH AS VECTOR FOR AGROECOLOGY IN COLLECTIVE GARDENS IN TOULOUSE REGION (FRANCE)

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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Agroecological transitions in collective urban gardens from Toulouse region have been studied through the prism of soil health (2011-2022). The socio-technical research project developed on four different collective gardening sites, consisted of: 1-surveys for hundred garden stakeholders to highlight the issues and practices, participation in meetings with the social centers in charge of animation and focus groups; 2-participative agronomy and environmental measurements and field observations, on soil quality; 3-analysis of the documentary corpus. A rise in the concerns of gardeners about the impact of their activities on soil health was observed: creating and enjoying landscapes, and taking care of the soil and biodiversity; developing social connections with transmission of practices, regular outside physical activity and healthier eating. Increased consideration of global health issues by all stakeholders consists in analyzes of soil quality and agroecological practices in gardens to promote the biodiversity and circular economy.

Four concepts emerged from the interviews: Global health, production of vegetables, living soil and social interactions. However, nuances exist between the studied sites accordingly to their history, environment and organization. These collective gardens are thus accessible laboratories for social and agroecological experimentation and they strongly participate to the urban ecosystem services directly linked to soil care.

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jardin en carré



GT 09 - 630 - P

UNCOVERING SOIL DYNAMICS: BIOLOGICAL AND PHYSICOCHEMICAL RESPONSES TO SUSTAINABLE AND CONVENTIONAL PRACTICES IN AGROECOSYSTEM MANAGEMENT

GT 09. SOIL HEALTH / GT 02. SOIL PHYSICAL CHEMISTRY

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Among today's global challenges, soil degradation demands urgent and effective solutions. Investigating soil ecological dynamics and comparing farming practices can offer critical insights into soil health and support the design of resilient agroecosystems. This study evaluated the effects of different management practices on soil biological and physicochemical properties through a two-year field experiment featuring a wheat–chickpea rotation and pollinator-friendly plant mixes aligned with EU Common Agricultural Policy eco-schemes.

The experiment was conducted in Caselle in Pittari (Salerno, Italy), using three replicates across six treatments (Fig. 1): wheat (Triticum aestivum L. cv Ardito) under sustainable management with organic amendment (P1); chickpea (Cicer arietinum L.) in rotation with P1 (P2); wheat under conventional management with mineral fertilizer (NPK) (P3); O.P. RUSTICO mix (P4); O.P. ECO-5 PLUS mix (P5); and native spontaneous vegetation (P6). Soil samples were collected before sowing (control) and at flowering (F), and analyzed in the first year for bulk physicochemical parameters and enzymatic activities in rhizosphere (MRP) and rhizosheath (MRS) compartments, following protocols of the Italian Ministry of Agriculture.

Principal Component Analysis (PCA) accounted for 59% of the total data variance, with PC1 (37%) driven by biological activity and organic matter, and PC2 (22%) reflecting soil textural and chemical traits. Sustainable management (P1) aligned with vectors of biological indicators (β-GLU, DHA, URE, organic C), whereas conventional management (P3) samples appeared more dispersed and oriented toward mineralogical variables. Control samples distinctly differed from flowering samples. Notably, F-MRP-P3 and F-MRS-P3 clustered in a PCA region opposite to enzymatic activity and organic nutrient indicators, suggesting a mineral-dominated soil with reduced biological function under conventional practices. In contrast, F-MRP-P4 and F-MRS-P4 diverged from other treatments, influenced by clay content, cation exchange capacity (CEC), magnesium, and pH, indicating an improvement in mineral nutrition.

These PCA outcomes were corroborated by cluster analysis and chi-square testing, which demonstrated a statistically significant association between treatment type and cluster grouping ($p = 0.041$). Overall, these preliminary results underscore that sustainable farming practices measurably enhance soil quality by fostering both biological activity and chemical balance.

ACKNOWLEDGEMENTS

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Figure 1 - The experimental field.

GT 09 - 637 - P

EFFECT OF THE LAND USE CHANGE FROM FOREST TO AGRICULTURE IN THE SOIL HEALTH STATUS IN ZAGORA, PILIO, GREECE

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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In the area of Zagora, in Mount Pilio, central Greece, forests have been cleared over past decades for the cultivation of apple trees. Currently there is a gradient of land use change, including the pristine environment (forest), abundoned apple orchards currently being deforested, and fully cultivated apple orchards. We tested the status of soil health in plots selected to represent these 3 steps of land use change (Fields A and B being two fully functional apple orchards at 270 m and 850 m of altitude, respectively, Field C a partially deforested abundoned orchard, and Field D pristine forest. Soil samples were obtained at two depths, 0-30 and 30-60 cm. We found that soil pH was acidic (from 5.02 to ca. 7) in all plots except for the surface layer of Field A (slightly alkaline). The particle size distribution did not change significantly across different land uses, ranging from loamy sand to clay loam. As for micronutrnet status, Cu was found rather elevated (up to 51 mg/kg) in the cultivated areas probably due to the continuous addition of phytoprotective materials, while Zn was rather low across all land uses. The marked difference was noted for organic C (OC), with forest having a 3-fold higher content than that of the cultivated fields, which had OC in the range of 1.5 to 2.5%, as expected for typical cultivated fields of Greece. We conclude that land use change had a marked effect on the soil health status of the studied areas across a gradient of land use change, with the most marked difference being soil C storage.

ACKNOWLEDGEMENTS

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GT 09 - 676 - P

INFLUENCE OF COVER CROPS AND TILLAGE ON SOIL ENZYME ACTIVITY RATIOS OF VINEYARD SOILS IN A SEMI-ARID CLIMATE (SANCHOSTHIRST PROJECT)

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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The EJP Soil SANCHOSTHIRST project (Cover cropS (CC) ANd soil health and climAte CHaNge adaptatiOn in Semiarid woody crops. The RemOte SensIng and furTHer scenaRIoS projecTions) aims to explore in depth the advantages that can be obtained by the use of management methods other than traditional tillage in woody crops. In previous works belonging to this project, the influence of the use of plant covers on enzymatic activities has been analysed. The aim of this work is to advance in the study of these biological variables by determining the influence exerted by soil management on soil enzyme activity ratios. In this work, the ten locations dedicated to vineyards in Spain belonging to the SANCHOS'STHIRST project have been studied. In each location, two near plots were sampled, one with cover crops and the other with tillage soil. In both plots, three composite soil samples were taken at depths between 0-10 cm and 10-30 cm. The samples dedicated to biological analysis were kept refrigerated from sampling until the analysis, in this case, of enzymatic activities. The enzymes analysed represent the main biogeochemical cycles: beta-glucosidase (b-glu) for the C cycle, urease (ure) for the N cycle, phosphatase (phos) for the P cycle and arylsulphatase (aryls) for the S cycle. To study the influence of handling on enzyme activity ratios, the following ratios were determined: aryls/b-glu, ure/b-glu, phos/b-glu, aryls/ure, aryls/phos and phos/ure. The influence of management on the ratios has been determined by studying Cohen's d for the ratios in soils with vegetation cover versus tilled soils. The results for the 0-10 cm depth indicated that more than 70% of the ratios were affected by management, showing differences depending on the location. However, in general terms, cover cropping promoted an increase in the ratios aryls/ure, aryls/phos, aryls/bglu and ure/bglu, while in the case of tilled soils an increase of the ratios phos/bglu and phos/ure ratios was observed. For the 10-30 cm depth samples, 68% of the ratios showed management effects, following a similar structure to that observed for the 0-10 cm samples. The results indicate that enzyme activity ratios vary between soil managements, the increase observed with cover crops compared to tilled soils may be due to a higher overall activity, while the increase in phos/bglu and phos/ure ratios may be due to a decrease in phos, because of the effects of tillage on the population of micro-organisms. These observed effects on enzyme activity ratios will have to be complemented with the corresponding nutrient data in addition to the genetic analyses that are being carried out in the project.

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GT 09 - 686 - P

IMPACT ASSESSMENT OF CAP MEASURES ON SOIL HEALTH IN SPAIN: SPATIO-TEMPORAL ANALYSIS OF SOIL COVER AND SOIL ORGANIC CARBON CONTENT

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Current agricultural policy initiatives within the European Union are promoting measures aimed at improving soil health. They could be evaluated from the effect of agricultural practices on soil indicators, using time series of both factors that are large enough to capture relevant variations.

Most monitoring systems that result in long-term time series focus exclusively on one of these factors. At the same time, projects derived from more recent policies that address both agronomic and environmental aspects do not yet have a minimum track record. As a result, research on this topic is limited and mainly comes in the form of meta-analyses or literature reviews.

In this study, we aim to assess the impact of conservation agriculture measures under the Common Agricultural Policy (CAP) on soil health. To this end, we conducted a quantitative analysis of the effect of soil cover management practices on soil organic carbon content (SOC) in agricultural soils in Spain by integrating of the longest available time series.

The soil component is sourced from the Land Use and Coverage Area Frame Survey (LUCAS) campaigns since 2009 [1], and the agricultural practices are obtained from the Spanish Crop Area and Yield Survey (ESYRCE), whose records date back to 2010 [2]. The latter has also been used as the basis for the design of the agricultural soil monitoring network in Spain, linked to its national Strategic Plan for the CAP (PEPAC).

In this way, 112 overlapping monitoring plots are identified (Fig. 1). Then, a Generalised Additive Mixed Model (GAMM) of the organic carbon content is built. It mainly considers the soil cover, whether the plots are farmed using conventional or minimum tillage versus no-tillage or vegetation or residue cover; the time ranges of practices with respect to the observations; as well as the crop type. Ultimately, we estimate the scale of those impacts and the extent over time.

In conclusion, this study highlights the significant impact of conservation agriculture measures under the CAP on soil health. By analysing soil cover management practices and their effects on SOC in Spain, we demonstrate how these policies can enhance soil quality. The integration of the longest available time series provides a robust assessment, underscoring the potential of these agricultural policies to promote sustainable soil management and contribute to long-term environmental and agricultural benefits.

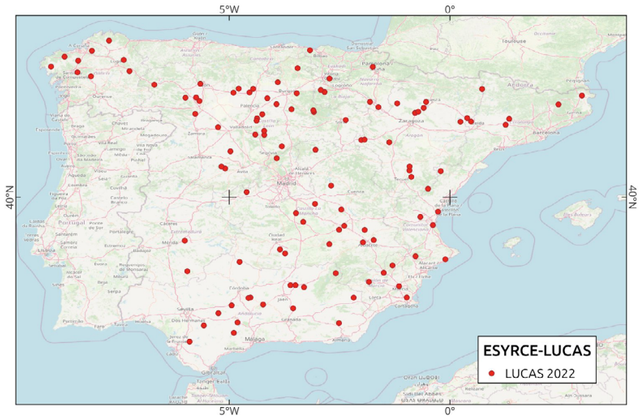
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Locations of overlapping plots between ESYRCE and LUCAS networks.



GT 09 - 687 - P

IMPACT OF CEREAL/LEGUME INTERCROPPING SYSTEM ON MYCORRHIZAL ABUNDANCE AND ITS INTERACTION WITH C SEQUESTRATION IN THE ORGANICALLY MANAGED CROPPING SYSTEM

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Arbuscular mycorrhizal (AM) fungi form mutualistic relationships with the majority of land plants and are an important part of the soil microbial community in natural and agricultural ecosystems. These fungi promote water and nutrient acquisition by their host plant and regulate the allocation of photosynthetic carbon to soil. Both crop variety and environment affect naturally occurring mycorrhizal abundance in roots, but the relative importance of those factors for mycorrhization is largely unknown. Therefore, this study aims to investigate the impact of cereal/legume intercropping systems on mycorrhizal abundance and C sequestration in the organically managed cropping system.

The field study experiment was conducted in the Lithuanian Research Centre for Agriculture and Forestry, Akademija, Kedainiai district (55°23′50″N, 23°51′40″E) in the organically managed cropping system in 6 treatments: two monocultures (spring barley and oat) and two compositions with legume intercropping (field pea and red clover). Mycorrhizal colonisation intensity (M%) of the root sample segments was determined by light microscopy (Trinchera et al., 2019) in the LAMMC Microbiology Laboratory. The potential of the C sequestration in the system was estimated by incubating the intercropping systems using the 13C-CO2 pulse labelling method (De Neergaard and Gorissen, 2004). The content of carbon isotope in plant roots and soil was assessed using a Thermo Flash EA 1112 elemental analyser interfaced to a Thermo Scientific Delta V Advantage isotope ratio mass spectrometer (IRMS) in the Isotopic Research Laboratory at the Centre for Physical Sciences and Technology.

Spring barley and oats M% ranged from 29 to 44% and 44 to 63%, respectively, across all samples. Averaged across all samples, the M% of oat was significantly higher than spring barley. The establishment of field pea intercrop has resulted in a significantly higher M% on spring barley and tended to decrease on oat. The red clover intercrop showed a positive effect on increasing M% on oat. The M% of spring barley and oat positively correlated with yield and showed significant differences in root biomass and C content in the soil.

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GT 09 - 696 - P

TRACE ELEMENTS IN THE SOIL-PLANT SYSTEM: ALFALFA AND NICKEL CASE STUDY

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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In Serbian soils, nickel (Ni) and chromium (Cr) are found in elevated concentrations over significant areas, often these elements origin is geochemical (from basic and ultrabasic rocks which account for about 4% of territory), but it can also be the result of anthropogenic pollution. Elevated Ni and Cr concentrations often occur in soils, which are generally suitable for agricultural production, including alfalfa cultivation. With the aim to select the nickel contaminated soil, agricultural soils from 15 locations in the central part of the country were examined for basic soil properties, and content and solubility of heavy metals. The soils with contrasting Ni concentrations (with slightly elevated and remediation Ni concentrations) were selected for further monitoring of alfalfa-soil interactions and elements translocation. The both soils were slightly acidic, moderately supplied with humus, nitrogen and available potassium, with clay mechanical composition. In addition, the inoculation with effective nitrogen-fixing bacteria rhizobia was performed at the beginning of trial, to ensure stable yields, and to examine the effect of strains on the accumulation of trace metals in the above-ground part of plants.

Lower solubility of metals in weakly acidic soil and adsorption on clay minerals possibly affected the lower mobility and accessibility of elements in the soil.

There is a pronounced accumulation of elements in the roots of the plant, which is confirmed by the translocation factor, which is generally less than 1. The Ni concentrations in alfalfa shoots varied depending on the strain, soil Ni and growing conditions, where inoculation with some strains reduced the Ni concentration compared to uninoculated plants. Concentrations of all tested elements were mostly in the range of common values for plants. In the soil with a higher content of Ni and Cr, significantly higher concentrations of these elements were found in all treatments, but a greater mass of alfalfa was also measured. The results indicate that inoculation of alfalfa with effective rhizobial strains showed potential for improvement of plants growth and phytostabilisation of trace elements in the soils. Further research is necessary to enable a better explanation of the relationships in the soil-plant-microorganisms system.

KEYWORDS

Soil, rhizobia, trace elements, alfalfa, soil quality.

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GT 09 - 706 - P

LINKING SOIL PROPERTIES WITH VINE RESISTANCE TO 2022 DROUGHT IN THE HILLS OF THE LANGHE AND MONFERRATO, ITALY

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The Langhe & Monferrato regions, in North-Western Italy, are historically of great importance for the viticultural-winemaking sector. The soils in the area develop on sedimentary rocks, are inherently fragile, on steep slopes, with low organic matter (OM) contents, and land use for vine cultivation favors compaction and erosion. These soils are likely to be poorly buffered with respect to the challenges posed by climate change, which causes an increase in extreme events, like the summer drought of 2022. The aim of this work was to assess the relationships between vine resistance to drought and soil characteristics, as a step in reaching the objectives of the LivingSoiLL project, and making the vine-soil-system of the area healthier.

In this work, we consulted the regional soil database, and isolated the topsoil data (upper 30 cm) of three of the most representative vine varieties of Langhe and Monferrato: Barbera, Nebbiolo, and Dolcetto. We considered site characteristics (elevation, slope, aspect), soil properties, and a proxy for plant health in the summer of 2022 (NDVI) to understand how soil properties varied across vine varieties, and how they regulated the level of plant stress in the area.

Most of the considered soils were classified as Entisols (90%), 68% of which had organic carbon contents <1%. The areas dedicated to Nebbiolo had a more frequent south-facing aspect, while the Barbera areas were less sloping and were located at lower average elevations. The Barbera soils were characterized by higher clay contents and lower sand contents than Nebbiolo and Dolcetto. The pH was lower under Nebbiolo cultivation, while the OM contents were slightly higher in Nebbiolo, as well as the C/N ratio, likely because of the ubiquitous presence of cover crops.

For Barbera and Dolcetto, the least water-stressed areas (with higher NDVI values) were associated to higher OM contents, while for Nebbiolo the least water-stressed areas were located where less OM was present. Both Barbera and Nebbiolo were least water-stressed where more sand was present (>25%), while Dolcetto was least stressed in presence of higher clay contents (>20%).

Soil texture seems therefore to be the main driver of the resistance to water stress in all soils, although vine vigor upon droughts is modulated by the contents of OM, likely thanks to the improvement in soil structure. Barbera and Dolcetto in particular benefit from higher OM contents to maintain vigor, while in Nebbiolo south-facing vineyards the resistance to drought seems to be depressed by the competition with cover crops and more closely associated to soil textural changes. These differences underline the need for variety-specific soil management practices to improve soil health in the ongoing climate change.

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GT 09 - 722 - P

INFLUENCE OF ORGANIC BIOPRODUCTS ON SOIL HEALTH: A COMPARATIVE STUDY IN LOAM AND SANDY LOAM SOIL

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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The use of organic amendments from animal and plant sources is key to improving soil fertility and promoting sustainable agriculture. In addition, there is a way to valorise residues. However, their impacts on nutrient dynamics and microbial activity vary depending on these products’ composition and the soil type where they are applied. This is one of the main goals of the Ecoloop Living Lab: to improve soil health using different strategies, including the use of digestate. However, testing its effect against other management methods or different soil types will enrich our understanding of the effects of these types of amendments on soil resources. For this reason, this study examines how digestate and pellets affect carbon and nitrogen dynamics in loam and sandy loam soils. Measurements included microbial respiration, nitrogen forms, organic matter, and carbon fractions. Three treatments (digestate, pellet, control) were applied in 132 incubated samples (30g soil/flask) under controlled temperature (25 °C) and humidity (70% of water retention capacity), over six time points (0–56 days).

Initial results indicate that digestate in loam soil induced a higher respiration rate than the control (22.6 times higher). The pellet presented 15% more respiration than the control condition. In the case of sandy loam soil, the treatments followed the same pattern, increasing the pellet 63-fold and the digestate 16.65% compared to the control. Furthermore, the percentage of nitrogen in the loam soil with digestate increased by 34% and the pellet 13% compared to the control. In the sandy loam soil, this increase was 19% with the application of digestate and 15% with the pellet compared to the control. The time factor showed a peak in nitrogen content in the first 3 days (+6%), stabilizing at 7 and 15 days in both soil types.

In conclusion, the application of digestate resulted in greater microbial activity and enhanced nitrogen mineralisation compared to pelletized compost. This effect was influenced by soil texture, with loamy soils showing a more pronounced response to digestate application.

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GT 09 - 765 - P

SOIL HEALTH INTERPRETATIVE FRAMEWORK TOOL, A STANDARDIZED APPROACH TO ASSESS SOIL HEALTH TRENDS ACROSS MULTIPLE CONTEXTS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil health monitoring is crucial for building sustainability and resilience in agroecosystems. This is a challenging task that requires the development of interoperable systems capable of performing comprehensive and systematic assessments, considering the impact of site-specific conditions on soil health [1]. The Soil Health Interpretative Framework Tool (SHIFT) was developed as an alternative to evaluate the current state of soils and monitor soil health, especially in agricultural soils [2]. This framework focuses on analysing soil health trends by comparing the performance of soil health indicators at specific sites with the prevailing performance in regions with similar conditions [2]. SHIFT uses the Z-score approach to standardize the data, create a common scoring scale, and assess soil health indicators' performances across multiple contexts. In this study, the utility of SHIFT was tested using soil organic carbon (SOC) stocks as a proxy of soil health and carbon sequestration function [2]. Variations in standardized SOC stocks' trends across different soil types, farming systems, and land management practices were explored. SHIFT proved to be sensible to site-specific conditions such as soil pedogenetic conditions and the intensity of agricultural systems [2]. This feature turns SHIFT into a versatile tool to address multiple stakeholder's needs, including monitoring and comparing soil health status from different geographical regions, assessing the impact of land management intensities in soils, supporting decision making and developing evidence-based policies to incentivize sustainable land use [2].

ACKNOWLEDGEMENTS

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GT 09 - 769 - P

GREEN COVERS TO COMBAT EROSION AND INCREASE SOIL HEALTH IN MEDITERRANEAN VINEYARDS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil health has become a central focus of European environmental policies aimed at halting ongoing land degradation. It is estimated that over 60% of European soils are affected by degradation, a problem further exacerbated by climate change. This issue is particularly severe in woody crops such as Mediterranean vineyards, where soils typically have low organic matter content and are highly susceptible to erosion.

One of the main objectives of the NOVATERRA project is to promote sustainable production in vineyards and olive groves through the implementation of improved soil management practices, including the use of cover crops. As part of this initiative, the present study evaluated the effects of green cover management on soil erosion mitigation and soil health enhancement in Mediterranean vineyards. Four soil management systems were compared using a randomized block design with four replicates: conventional tillage (CT), no-tillage with spontaneous natural cover (NGC), no-tillage with a sown cover mixture of 80% grasses and 20% legumes (SGC), and no-tillage with a sown mixture of 90% grasses and 10% annual flowering species (FGC).

Surface soil samples (0–20 cm) were collected in both spring and autumn from two positions within each alley: the steeper area (10–20% slope; S) and the depositional area (D). Samples were analyzed for various chemical and biochemical indicators of soil health, including pH, electrical conductivity (EC), organic matter content, total nitrogen, soluble nutrients, microbial biomass carbon and nitrogen, and enzymatic activity profiles. Additionally, aerial imagery was used for plant phenotyping at the fruit development stage (BBCH 70–79) and for assessing grape production at harvest.

The results showed a decrease in available nutrients, particularly nitrates and phosphates, and an increase in soil organic carbon under green cover treatments, especially FGC in spring and NGC in autumn. Grape production was slightly lower in green cover treatments; however, the differences were not statistically significant.

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GT 09 - 772 - P

CONTRIBUTION OF COVER CROPS TO SOIL QUALITY IN YOUNG VINEYARDS UNDER CLIMATE CHANGE SCENARIOS

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The use of cover crops in newly established vineyards can reduce vulnerability to climate change and erosion risk by promoting soil health and protecting the soil surface. However, there is a lack of information regarding which cover crop species are most suitable and whether vine variety may influence their performance. This research evaluated the contribution of two leguminous cover crops to soil quality in young (first-year) vineyards under semi-controlled conditions simulating climate change scenarios. The experiment was conducted in a greenhouse and considered four factors: (1) temperature (current vs. +2 °C), (2) vine variety (Tempranillo and Airén), (3) type of cover crop (bare soil, Trifolium subterraneum L., Medicago truncatula Gaertn.), and (4) water availability (high vs. -15 %). The resulting 24 treatments were arranged in a randomised complete block design with four replicates. Each experimental unit consisted of a mesocosm. Three months after the start of the experiment, and one month after mowing the cover crops and applying them as mulch, soil sampling was conducted.

The results showed a significant effect of the cover crops on the properties analysed, with increases in volumetric water content, water-stable aggregates, substrate-induced respiration, and soil pH compared with bare soil. A temperature increase of +2 °C significantly reduced soil organic matter in Trifolium compared with the current temperature scenario, while Medicago was more effective at increasing soil organic matter under low water availability (-15 %). Medicago also increased the proportion of water-stable aggregates compared with the control. A significant effect of vine variety on soil water content was observed, with Tempranillo reducing this parameter.

These results highlight the importance of strategically selecting a suitable cover crop species and vine variety—an essential consideration for ensuring the viability of young vineyards under climate change scenarios.

KEYWORDS

Soil management, soil health, legumes, Tempranillo, Airén.

GT 09 - 775 - P

COVER CROPS UNDER GLOBAL WARMING SCENARIOS: IMPLICATIONS FOR SOIL HEALTH INDICATORS

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Agricultural systems are increasingly challenged by climate change, particularly due to rising temperatures and fluctuating precipitation patterns. This study assessed the impact of different cover crops (CCs) on soil health under various climate change scenarios. An average temperature increase of +1.5 °C was simulated relative to the mean temperatures recorded from October to December. Two factors were evaluated: (1) rainfall, with three levels (+10%, -5%, and -20% compared to the historical average), and (2) cover crop types, with five treatments: no CC; Camelina sativa L.; Hordeum vulgare L.; Vicia sativa L.; and a mixture of the three species. Mesocosms filled with top soil from a Typic Calcixerept located in central Iberia were placed in a controlled growth chamber. At the end of the experiment, microbial communities (fungi – ITS, bacteria – 16SB, archaea – 16SA), pH, electrical conductivity (EC) of the rhizospheric soil, and CC biomass were evaluated.

The results showed that Vicia sativa L. promoted archaeal abundance, while Hordeum vulgare L. enhanced fungal and bacterial populations compared to the no-CC control. Vicia sativa L. also produced higher biomass and was highly sensitive to rainfall, increasing under high rainfall (+10%) and declining sharply under low rainfall (-20%). In contrast, the species mixture exhibited biomass stability across rainfall treatments. Biomass was negatively correlated with EC and positively correlated with pH. Moreover, EC was significantly correlated with microbial abundances, suggesting it may directly influence microbial dynamics.

In conclusion, CCs affect key soil health parameters and, if properly managed, can help protect soil and enhance its resilience to climate change.

KEYWORDS

Temperature, rainfall, soil microbiota, sustainable agriculture.

GT 09 - 804 - P

SOIL HEALTH BENCHMARKING OF ROW CROPPED SOIL IN NORTH AMERICA

GT 09. SOIL HEALTH / GT 16. CONNECTING PEOPLE AND SOILS

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We expect changes in soil functioning to occur in highly managed row crop agricultural production systems when management changes are implemented, e.g., eliminating or reducing tillage, adding cover cropping, and reducing inputs. However, assessing such changes across a large areal extent, such as a portion of a continent is difficult because of the expected differences in soil capability due to variability in inherent soil properties, climate, and the extent and duration of management practice change. The Soil Health Institute aspires to measure and model how we could expect soils to change in row-cropped agricultural systems and provide an assessment of those changes that are both scalable across large geographies and relevant to a farmer or land management decision-making at the local, field scale. We will present the method, modeling approach, and outcomes of such endeavors applied across the Southern USA cotton belt, Ontario, CA, and a part of Iowa in the Midwestern USA. Soil health indicators that we measured include soil organic carbon concentration, carbon mineralization potential, aggregate stability, and available water holding capacity. Beyond publishing such results in scientific literature, we will also show that our thinking is evolving for sharing the results with farmers and supply shed purchasers of agricultural crops, and our approach to scale this endeavor to complete an assessment of North America.

ACKNOWLEDGEMENTS

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GT 09 - 867 - P

SETTING UP A NATIONAL MONITORING PROGRAM TO IDENTIFY UBIQUITOUS AND POTENTIAL HARMFUL SUBSTANCES IN SOIL AND SEDIMENT IN THE NETHERLANDS

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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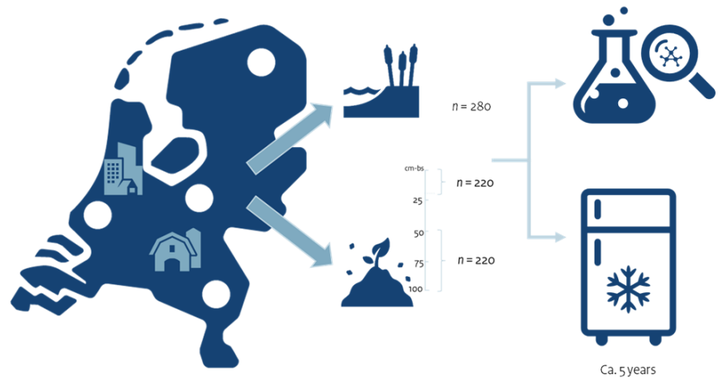
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Non-standardized substances are substances that currently lack established legal standards regarding permitted concentrations in the environment. The absence of such standards complicates efforts for regulatory authorities and businesses to provide guidelines for the safe use and management of these substances and/or the materials in which they may be present (such as soil and sediment). A well-known example of this challenge is the current PFAS crisis.

Therefore, the pilot Monitoring for Non-standardized Substances (pMNS) was set up in early 2024 with the aim to develop a novel national approach for detecting various non-standardized substances that co-occur and are diffusely spread across both soil and sediment in the Netherlands and may pose environmental risks. To achieve this, 440 soil and 280 sediment samples with different land use types (including urban and rural) are being collected from various locations across the Netherlands. A part of each sample is being analyzed for initially five groups of substances: polychlorinated n-alkanes (also known as chlorinated paraffins), polybrominated diphenyl ethers, glyphosate and its transformation product AMPA, pyrethroids and PFAS precursors. The selection of the five groups of substances was based on their persistence, toxicity, bioaccumulation and emission potential. Variability among the substance groups, including differences in their use and chemical properties, was also taken into account. The rest of the sample is stored under controlled conditions for future analysis of other substances and other purposes. Indicative risk thresholds for health and background levels will be derived for the substance groups that are found to be present, which can be used by regulatory authorities. This poster presents the aim, methodology, challenges, preliminary results and potential next steps of the pilot project.

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GT 09 - 889 - P

POXC DETECTS EARLY SOIL HEALTH GAINS FROM BIODIVERSIFICATION IN NO-TILL SYSTEMS

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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Land-use change from natural ecosystems to agriculture leads to significant biodiversity loss, consequently reducing critical soil-related ecosystem services such as nutrient cycling and carbon storage. Introducing biodiversity into agroecosystems through crop rotation and multispecies cover crops can improve soil health and increase systems resilience. This study evaluated early biological responses to a biodiversification gradient under no-till using sensitive soil health indicators. A long-term no-till field experiment was established in South Brazil in 2018, comparing three cropping systems: monocrop (continuous soybean in summer, oats in winter), rotation (soybean/maize alternation in summer, oats/wheat in winter), and rotation with winter cover crop mixes (Fabaceae, Poaceae, and Brassicaceae mixes). The experimental design included three blocks with unequal replication (3 for mono-crop, 6 for rotation, 12 for cover crops) to minimize temporal bias from annual weather variability. Soil samples were collected in 2023 and analyzed for three biological soil health indicators: soil organic carbon (SOC, by dry combustion), soil protein (ACE protein, citrate-extractable), and permanganate oxidizable carbon (POXC). Linear mixed models including block as a random effect were used to assess treatment effects. POXC was the most responsive indicator, increasing from 336.6 mg/kg in monocrop systems to 417.3 mg/kg in rotation and 426.3 mg/kg in cover crop treatments. A significant linear trend along the biodiversity gradient was observed ($p = 0.038$), with POXC increasing by 24.0% from mono-crop to rotation and 26.7% from mono-crop to cover crops. In contrast, SOC and ACE protein did not show statistically significant differences within this timeframe. These findings suggest that POXC is a sensitive, short-term indicator capable of detecting early improvements to soil biological health following biodiversification. Therefore, POXC is a useful tool for guiding and validating the efforts of farmers transitioning to more sustainable practices. Employing sensitive biological indicators like POXC enables researchers, extension agents, and consultants to demonstrate early progress to farmers, helping motivate the long-term adoption of soil health strategies such as crop rotation and cover crop integration. Early detection of soil function improvements offers an accessible, science-based approach to support the ecological intensification of agriculture.

GT 09 - 910 - P

REDUCED TILLAGE INTENSITY INCREASES SOIL ORGANIC MATTER AND FAVORS BACTERIAL K- OVER R-STRATEGISTS

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Sustainable agricultural practices aim to improve soil health, which is often linked to the promotion of microbial activity. Ecological theory divides microbes based on their lifestyle into K-strategists and r-strategists. The former utilizes recalcitrant organic sources and grow more slowly than the latter, which have faster growth rates and consume easily degradable organic material. While it has been hypothesized that sustainable farming practices promote soil health and bacterial diversity by increasing the portion of K-strategists, there is a lack of validation from field generated data. Here, we aimed to test this hypothesis by analyzing data from a long-term field trial in Saxony-Anhalt, Germany. The field experiment included two different conditions of tillage intensity (cultivator vs. plough) and N-fertilization intensity (extensive vs. intensive). We analyzed soil properties and bacterial communities based on 16S rRNA gene amplicon sequencing from bulk soil and rhizosphere habitats obtained from plots under grain maize cultivation (2019–2021) using linear mixed-effects models. We found that reduced tillage (cultivator) improved soil organic matter and increased bacterial diversity in both soil habitats. In addition, the relative abundance of several taxa increased under reduced tillage and these taxa belonged to known K-strategists. Organic matter correlated with the cumulative relative abundance (CRA) of bacteria that positively responded to reduced tillage. However, diversity (richness) weakly correlated with organic matter and the CRA microbes. We mapped the 16S rRNA genes of these responders to publicly available genomes and analyzed their growth rates based on codon usage and genome size (packages gRodon2 and CheckM2). Genomes associated with bacterial responders to reduced tillage were significantly smaller, and corresponding organisms likely exhibit slower growth rates compared to those associated with responders to intensive tillage. This was apparent for bulk soil, but not for the rhizosphere. However, this indicated a shift in tillage intensity from r- to K-strategists, which explains the strong correlation between the ASVs that positively responded to reduced tillage and organic matter. These results support the hypothesis for reduced tillage, since it promoted soil organic matter and bacterial diversity by increasing the portion of K-strategists. In summary, K-strategist abundance could serve as a robust indicator for soil health, since their abundances likely contribute to higher organic matter concentrations in soil environments.



GT 09 - 911 - P

COMMON MEASUREMENTS OF SOIL HEALTH FOR CANADIAN FORESTS

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Legislative and policy shifts around soil are occurring globally – including in Canada. Much of the change in Canada is being driven by the twin concepts of soil health and soil degradation. A lot of research is rightly focused on determining how to monitor and measure soil health in agriculture. Yet Canada is also a nation of forests, and these forests are undergoing unprecedented levels of disturbance (e.g., harvest, wildfire, climate change etc.). Our project set out to address this research gap by assessing common measurements of soil properties for national forest soil health reporting. Here we present our objectives, study design, and progress to date related to our field program. Our approach is to leverage 17 experimental forest research sites spread from coast to coast focused on key soil types under ecologically and economically important tree species. Each site includes a mature stand to which at least one disturbance type (harvest, fire, or salvage-logging) is compared for common soil physical, chemical, and biological properties. Through a standardized field sampling protocol and a single analytical laboratory, we aim to identify common indicators of change in Canadian forest soils.

GT 09 - 925 - P

COVER CROPS MAY IMPROVE SOIL HEALTH IN VEGETABLE PRODUCTION SYSTEMS OF PUERTO RICO

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Agricultural sustainability cannot be achieved without healthy soils. Cover crops can improve soil health. We evaluated the impact of cover crops as a conservation practice on soil health in two commercial vegetable farms in southern Puerto Rico. The soil at farm A was a Typic Haplocalcids and Farm B was a Typic Haplusterts. In Farm A three annual cycles were evaluated with three treatments: conventional management (CM) with voluntary weeds, nitrogen-contributing cover crops (NCC), and carbon-contributing cover crops (CCC). At Farm B, two cycles were evaluated with two treatments: CM and a mix of cover crops contributing N and C (CC). Each cycle lasted approximately one year. At Farm A, the cover crop treatments increased soil health by significantly improving several indicators compared to CM. The evaluated cover crops increased the moderately stable and active soil organic carbon fractions, soil biological and enzymatic activity, aggregates size distribution, and fertility, as reflected in changes in soil organic matter (SOM), permanganate oxidizable carbon (POX-C), 3-day Respiration, β-glucosidase, β-glucosaminidase, exchangeable P, extractable K+, and cation exchange capacity (CEC). At Farm B, soil health was not affected by conservation practices. Inherent soil properties associated with soil texture may explain the improved response to cover crops in Farm A.

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GT 09 - 934 - P

MONITORING SOIL HEALTH INDICATORS IN FARMS IN THE FRAMEWORK OF ADAPTIVE PRACTICE ASSESSMENT IN NAVARRE (SPAIN)

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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In response to the predicted impacts of climate change, and with the objective of enhancing the resilience of the region of Navarra (N Spain), the Life Nadapta project has carried out various studies across multiple fields (including healthcare, infrastructures, natural ecosystems, urban areas, water management, forestland and agriculture). One of these focuses on the implementation of adaptive strategies , including the assessment of soil health and the potential to boost its resilience through different management practices. The agricultural practices evaluated include conservation agriculture, the application of organic amendments, and the use of crop rotations. The aim of this study was to evaluate the impact of these approaches on three pre-established soil quality indicators: bulk density, water holding capacity, and organic carbon storage on actual farm fields, in the framework of the new EU Law on Soil Health monitoring

After a zonification process based on agroclimatic distribution and the identification of different bioregions, the region of Navarra was divided into 12 distinct zones. Within each of these, the most representative agricultural management practices were selected from a network of over 150 farming plots. Paired comparisons were then carried out on plots within the same soil unit but under contrasting management strategies, in order to assess the impact of the selected practices on soil health. As a result of this extensive plot selection, 11 representative plots from some pioneer farms were chosen from the network to continue a detailed study on the evolution in time of the indicators described above, several years after the initial assessment, allowing for a comparison between conventional and adaptive management practices in terms of their effects on soil health indicators at the farm level. The ultimate goal is to define a regional Resilient Soil Management Plan.

This work presents the methodology followed during the second phase of the project for the selection and monitoring of these plots, as well as the main results obtained from their continued assessment. In addition, it includes the outcomes of the economic study carried out on the monitored plots.

Once the results from the first phase were analysed and the relationships between the indicators and their effects examined, it was concluded that organic carbon stock played a key role as a descriptor of soil condition under different management practices. This was not only due to the properties it imparts to the soil itself (as it is a parameter linked to many soil functions such as biodiversity, erosion control, etc.), but also because of the well-established relationship, reflected in some of the strategies evaluated in this project (application of organic amendments), with bulk density and water holding capacity. For this reason, it was decided that the criteria for plot selection for the Resilient Soil Management Plan would be carried out in two phases:

- In the first phase, greater emphasis was placed on carbon accumulation in the soil, selecting farm fields where a positive response in carbon stock had been recorded alongside neutral or positive effects in the other two indicators (bulk density and water holding capacity). Following this initial screening, seven fields were selected, belonging to different farms in the region. Subsequently, with the aim of providing a broader range of locations from which to choose, those showing neutral effects on carbon accumulation were also included (while maintaining the same criteria for bulk density and water holding capacity as before), resulting in a final selection of 16 fields.

- In the second phase of the selection process, starting from the group of fields proposed in the previous stage, we carried out the selection of those to be monitored in the following years. This was based on an evaluation of the ease of monitoring, considering the willingness of the farmers and their future management prospects.

As a result of this selection process, 11 farm fields were successfully chosen for ongoing monitoring, where we were able to compare the effect of a conventional management with the adaptative ones on soil health indicators.

To standardise sampling conditions across plots, visits were scheduled at comparable stages of the crop cycle. Two types of samples were collected: disturbed and undisturbed, each taken at two soil depths (0–15 cm and 15–30 cm). Undisturbed samples were gathered in 3 sets, each comprising 9 subsamples per plot. Additionally, three bulk density rings were collected from the undisturbed samples in each plot.

Among the management practices assessed, the application of organic amendments was observed to be the most effective in preserving soil organic carbon levels. However, although this approach generally succeeded in maintaining stable carbon concentrations, no clear increases with time (within 5 years) were recorded to date. In zone 1 (arid Mediterranean), however, the rise in organic carbon within amended plots was accompanied by a decline in soil water holding capacity, indicating that other variables such as soil texture or carbonate content might be at play. Meanwhile, two out of three conservation agriculture fields showed a reduction in their carbon stocks between the project's start and end, consistent across both zones examined. Crop rotation, tested in zone 7 (Oceanic-Mediterranean transition area), was unique in exhibiting a neutral impact across all three soil quality indicators. Water holding capacity was the most variable indicator throughout the study.

These results highlight the necessity of conducting measurements under real farm conditions to fully understand the impacts of these management strategies on soil health, and the expected resilience of agrosystems in future climate scenarios.

For the economic study, in order to study if there was any relationship between the expenses derived from a specific management and the carbon sequestration values recorded, these two variables were combined to develop scatter plots that allowed a simultaneous visualization of all the groups of plots studied.

Based on the observed results, and considering the fluctuations in input prices between seasons as well as the specific circumstances involved such as each farmer's individual approach to managing their fields, it is concluded that there was no direct correlation between a particular management practice and the investment-to-carbon concentration ratio. Consequently, each case should be analysed independently, with tailored monitoring carried out to identify potential trends in management evolution.

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GT 09 - 942 - P

ASSESSING THE IMPACT OF MICROPLASTICS IN U.K. WOODLAND SOILS

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Research on microplastics has focused heavily on aquatic environments, leaving a gap in understanding their presence and effects in terrestrial ecosystems, particularly woodlands which are crucial for the health of many species and ecological functions. One overlooked source of microplastic pollution is woodland management tools such as tree guards and cable ties. This research aims to address this gap by assessing the impact of microplastics from these sources on U.K. woodland soil to support the creation of policies to better regulate plastics use and waste management. This research is timely given the increase in tree planting initiatives to meet climate change mitigation targets.

To do this, a 15-month burial experiment is being conducted to explore how varying concentrations, types, sizes and shapes of microplastics affect woodland soil chemistry and microbial respiration. The impact of the soil on the microplastics physical and chemical properties is also being monitored. The findings will be shared with woodland management organisations and woodland management tool manufacturers to raise awareness of microplastics as a potential pollutant in woodland ecosystems.

GT 09 - 955 - P

THE ROLE OF THE ACTIVE PROKARYOTE COMMUNITY IN PHYTOREMEDIATION OF METAL-CONTAMINATED SOILS

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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Phytoremediation of metal-contaminated soils relies not only on the capacity of plants to tolerate and accumulate toxic metals but also on the complex interactions with soil microbial communities contributing to metal availability, root uptake, and key biogeochemical processes. While most studies often focus on the total microbial community, which also includes inactive taxa and relic DNA, recent advances highlight the importance of studying the active microbial community for accurately understanding soil processes and plant–microbe interactions. Thus, the goal of this study was to advance understanding of how the potentially active prokaryote community influences phytoremediation outcomes and nutrient cycling under varying metal contamination levels.

A greenhouse pot experiment was conducted using the metal-hyperaccumulating plant Arabidopsis halleri grown in three agricultural soils with naturally varying metal (Cd, Pb, Zn) contents: low, mid, and high-metal. The soil prokaryote community was assessed through 16S rRNA transcript sequencing, nitrogen transformations and carbon use efficiency by stable isotope tracing. Nutrient pools were quantified by colorimetric analysis, and metal concentrations via ICP-MS.

Higher metal levels significantly reduced the alpha diversity of the potentially active prokaryote community in bulk soil, particularly among common and dominant taxa (Hill numbers 1 & 2). In the rhizosphere, however, only dominant taxa (Hill number 2) were negatively affected by increasing soil metal contents. Variance partitioning analysis revealed that soil available metals explained 5% of the variation in bulk soil microbial composition, with an additional 18% jointly explained by metals and nutrient pools. In contrast, rhizosphere communities were not directly influenced by soil available metals alone, with a shared contribution of 17% from metals and nutrients. These results suggest that rhizosphere microbes are more buffered from soil metal stress, likely due to plant-mediated effects.

Microbial taxa associated with soil metal content differed between compartments: two phyla were positively related to metals in the bulk soil, whereas four were associated with the rhizosphere (Actinobacteria & Firmicutes only related to rhizosphere). Additionally, genera within Proteobacteria, Actinobacteria, and Firmicutes were associated with higher plant metal accumulation. Increased soil metal levels also led to enhanced N and P mineralization and a higher metabolic quotient, particularly in the rhizosphere.

The results suggest that root activity can modulate the resilience and adaptability of the potentially active prokaryotic community to metal stress, leading to distinct outcomes for nutrient cycling and metal accumulation. Our findings emphasize the importance of focusing on the potentially active microbial community to reveal microbial contributions to phytoremediation, especially under conditions of environmental disturbance like metal stress.



GT 09 - 958 - P

MICROBIAL ACTIVITY IN CONTAMINATED AREAS: THE CASE OF NORTHERN FRANCE

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Soil degradation is currently an important issue across Europe, posing significant risks to ecosystem services and environmental sustainability. In response, the scientific community is making great efforts to define soil health and to propose robust, sensitive indicators of soil health. In this context, soil microbial activity plays a central role, yet remains only partially understood due to its dynamic nature.

Soil microbial enzymes have been recognized as promising bioindicators due to their role in nutrient cycling (C, N, P, S) and their sensitivity to environmental stressors. However, enzyme activity is influenced by various factors including soil texture, seasonal changes, vegetation cover, and contamination, complicating the establishment of reference values and thresholds.

This research is studying microbial enzymatic activity in contaminated soils from diverse European sites (France, Greece, Italy, Spain and Poland). Initial findings are presented from a particular case study located in the north of France (Carrière sous Poissy, Île-de-France), where extensive industrial and urban dumping led to a complex contamination profile, including asbestos, plastic and heavy metals. The analysis includes the activities of urease (URE), β-glucosidase (β-GLU), arylsulfatase (ARS), alkaline phosphatase (PAK), and acid phosphatase (PHOS), along with the soil's cellulose degradation capacity, as indicators of microbial functioning under contamination stress.

This study is part of the broader investigation spectrum of the HE EDAPHOS project which, following Environmental Risk Assessment (ERA), implements Nature-Based Solutions (NBS) to achieve soil rehabilitation in Europe.

Within this context, the broader objective of this research is to identify robust microbial indicators of soil health, define context-specific thresholds, and enhance their interpretation for use in ERA and remediation monitoring.

GT 09 - 965 - P

AN UNSEEN BARRIER: EXPLORING THE UNKNOWN IMPACTS OF SOIL WATER REPELLENCY ON FOOD AND FIBER SECURITY IN A CHANGING CLIMATE

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Soil health is essential for healthy, productive lands. Farmers and landowners are turning to practices that aid in conserving and improving biological, physical, and chemical soil functions. More information is needed on how these practices, such as cover crops, tillage, and irrigation, influence the development and occurrence of soil water repellency. Soil water repellency is a soil property that causes soil to have limited wetting capabilities, restricting soil infiltration and hydraulic conductivity. In agroecosystems, soil water repellency impacts plant available water, soil health, and plant health. Hydrophobic coatings cause soil water repellency, which is commonly enhanced during dry periods. Current climate change models predict rising temperatures and more frequent extreme weather events, such as droughts. Such events will likely increase the occurrence and severity of soil water repellency. As climate change continues to impact the world, it is more important than ever to understand how in-field management practices may affect the development and occurrence of soil water repellency. This poster will explain (a) how climate change is anticipated to influence the development and occurrence of soil water repellency (b) review how soil water repellency is affected by in-field management practices, and (c) how soil health management practices, and soil water repellency are all interlinked and may affect food and fiber security in the near future



GT 09 - 967 - P

DECISION SUPPORT SYSTEMS FOR SUSTAINABLE SOIL MANAGEMENT IN THE MEDITERRANEAN REGION: STATE OF THE ART AND CRITICAL DATA REQUIREMENTS

GT 09. SOIL HEALTH / GT 09. SOIL HEALTH

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One of the objectives of the project “SOIL health monitoring and information systems FOR sustainable soil management in the MEDiterranean region” (SOILS4MED) PRIMA-funded project is to demonstrate the capacity of soil data and information to feed decision support systems (DSS) for sustainable soil and water management and for land degradation neutrality (LDN) in the Mediterranean region. To this end, it has been performed a review and analysis of DSSs and their critical data requirements for achieving the mentioned objectives. Through a comprehensive assessment of active platforms (both scientifically proposed and privately developed), the study identifies key data needs, conceptual approaches, and current limitations in regional implementation. The review includes DSSs focused on soil functions, regulatory tools, and threshold values, as well as the need of pedotransfer functions (PTFs), which are essential for filling gaps in relevant soil data. The findings show that most DSSs were developed outside the Mediterranean context and often lack calibration or adaptation to regional soil and climate conditions. Furthermore, there is no harmonized framework for the application of DSS at different spatial scales, and regulatory schemes and threshold values vary greatly between countries and subnational regions, resulting in fragmentation. Prominent DSSs, such as MicroLEIS, SOILNAVIGATOR, SOILCONSWEB, and LANDSUPPORT (GeOC tool), partially or fully incorporate the concept of soil multifunctionality, considered essential for achieving sustainable land management. Preliminary results indicate low adoption of these tools, mainly due to data complexity and a lack of intuitive interfaces.

The study concludes that, to improve the usefulness of DSSs in the Mediterranean Region, it is essential to: (i) increase the availability and harmonization of Soil Information Systems (SIS) with comparable attributes, methods, and formats; (ii) develop robust and regionally adapted PTFs; and (iii) define interpretable threshold values to assess soil functions and guide management decisions. These aspects will be addressed in later phases of the project, in close collaboration with stakeholders and in line with supranational initiatives such as the EU Soil Strategy for 2030.

GT 09 - 999 - P

BENEFITS OF REGENERATIVE AGRICULTURE ON SOIL PH AND MICROBIAL INDICATORS IN COMPARISON TO CONVENTIONAL TILLAGE

GT 09. SOIL HEALTH / GT 04. SOIL BIOLOGY

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The global issue of climate change is closely related to agriculture practices. The search for sustainable technologies that mitigate climate change while maintaining crop production and increasing soil organic carbon stocks, thus reducing greenhouse gas emissions, has led to the development of regenerative agriculture. This approach, aligned with the principles of carbon farming, aims to enhance the long-term capacity of soils to sequester atmospheric carbon (primarily CO2).

The objective of this study was to evaluate the impact of regenerative agriculture on several biological indicators of soil quality that are relevant to reducing the carbon footprint. A field experiment was conducted on previously conventionally managed arable land in a warm and dry region of the Czech Republic to compare two agromanagement systems over three years: (i) conventional tillage and (ii) a no-till regenerative system incorporating legumes as catch crops.

Soil properties were compared in the third year at the end of growing season with winter wheat as the cash crop, sown directly into stubble. The regenerative system significantly increased soil pH (from around 5.5 to > 7.0), dehydrogenase activity (indicative of soil organic matter turnover), urease activity (reflecting nitrogen cycling), and bacterial biomass (measured as 16S rDNA copy number) across three soil depths (0-5 cm, 5-15 cm, and except for urease and 16S rDNA, 15-30 cm).

The findings demonstrate that regenerative agriculture practices can substantially improve soil biological quality, thereby supporting soil fertility and enhancing soil´s potential to store soil organic carbon in the long term.

ACKNOWLEDGEMENTS

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GT 09 - 1004 - P

URBAN GREEN ROOF SOILS AS CARBON RESERVOIRS: FIELD-BASED ANALYSIS OF PLANTING SYSTEMS AND SOIL PROFILES

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Urban green roofs, as a component of climate-resilient infrastructure, provide a range of environmental benefits, including carbon storage. However, most existing studies have focused primarily on the carbon uptake of rooftop vegetation, while quantitative assessments of carbon storage within green roof soils remain limited. Given that soil is a major carbon reservoir in terrestrial ecosystems, quantifying the carbon storage capacity of green roof soils is essential for supporting urban carbon neutrality strategies.

This study conducted field-based monitoring to evaluate the carbon storage capacity of rooftop soils and compare variations across different greening types. Four rooftop greening sites were selected in Seoul and Goyang city, South Korea, encompassing a range of effective soil depths from lightweight systems (10 cm) to intensive systems (over 30 cm). Planting types were classified from mono-layered herbaceous systems to multi-layered designs incorporating shrubs and trees. The substrate compositions also varied across sites, including perlite-based lightweight soils, biochar-amended substrates, and general artificial soils.

Soil samples were collected at multiple depths in each site to measure total carbon (TC), soil organic carbon (SOC), bulk density, and effective soil depth. Based on these parameters, soil carbon stock per unit area was calculated. Additionally, thermogravimetric analysis (TGA) was employed to examine the composition of carbon stored in the soil, identifying the proportions of organic carbon, inorganic carbon, and black carbon to assess the qualitative characteristics of carbon storage.

The results revealed meaningful differences in soil carbon storage depending on planting type, soil depth, and substrate composition. In particular, biochar-amended soils exhibited higher carbon storage compared to conventional lightweight substrates. In some cases, carbon accumulation levels approached those observed in long-established park or forest soils, suggesting that green roof soils have the potential to function as long-term carbon reservoirs within urban environments.

This study provides a practical evaluation of carbon storage in green roofs through real-world monitoring and presents a quantitative range of carbon storage by greening and planting types. The findings offer valuable baseline data for urban carbon accounting and the development of climate-resilient green space strategies. Future research will include long-term monitoring of soil respiration and carbon fluxes to further assess the sustainability of soil carbon storage in rooftop systems.

ACKNOWLEDGEMENTS

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GT 09 - 1012 - P

DEVELOPING A SOIL MONITORING SYSTEM FOLLOWING REGIONAL AND EUROPEAN POLICIES – CASE OF WALLONIA, SOUTHERN BELGIUM

GT 09. SOIL HEALTH / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Soils provide essential Ecosystem Services (SES) to society. However, human activities, practices, and consecutive climate change threaten soil through various degradation: erosion, compaction, loss of OM and biodiversity, acidification, pollution, etc. Assessing soil health is therefore essential. Knowing soils capacity to provide essential SES, we will be able to act consequently to improve Walloon soils protection.

Therefore, a Soil Monitoring System is currently under development in Wallonia. For the 1st time, the Walloon Soil Monitoring (WMS) will provide a state of soil health all over Wallonia by integrating all land uses and occupations. Various chemical, physical and biological indicators are tested according to their: sensitivity, representativeness of SES, methodological practicality, complementarity and cost... The indicators, sampling schemes, protocols in-field and in laboratories are selected considering the Walloon Soil Decree, the LULUCF regulation and the upcoming Soil Monitoring Law. We work collaboratively with different universities and laboratories in Belgium to create a fluid and thorough chain of treatment from the field to the laboratories. Let us introduce you to the WMS and the challenges along its development.

ACKNOWLEDGEMENTS

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GT 09 - 1019 - P

MULTIDISCIPLINARY SOIL HEALTH ASSESSMENT IN DEGRADED EXTENSIVE PASTURES PRONE TO LOCUST OUTBREAKS IN SARDINIA, ITALY

GT 09. SOIL HEALTH / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The objective of this study was to assess the soil health, by means of an interdisciplinary set of indicators, in extensive and semi-extensive Mediterranean pastures variably affected by overgrazing and land degradation and susceptible to occasional locust outbreaks, located in central-northern Sardinia (Ottana plain). The soil assessment was conducted at 23 sites selected based on stakeholder-driven indication of the soils most affected by degradation and by locust oviposition using an integrated set of soil health indicators encompassing physical (including texture, bulk density -BD-, aggregate stability, and soil penetrometer resistance -SPR-), chemical (including pH-H20, soil organic carbon -SOC- content, CaCO3 content, total nitrogen -N- content, assimilable phosphorus -P-), biochemical (including dehydrogenase) and a set of field-based soil condition indicators.

Statistic analysis was done by using the software STATISTICA [1], and consisted of: i) a test of the normal distribution of the dataset using Shapiro-Wilk; ii) a Pearson's correlation matrix; iii) linear regression, and iv) a Principal Component Analysis (PCA).

The preliminary results showed considerable variability among the investigated variables with a normal distribution. Principal Component Analysis (PCA) showed that the two main components explained alone 73.0% of the total variance. The first component distinguished variables related to chemical fertility from those associated with soil compaction (BD and SPR), suggesting a gradient of soil quality. The inverse relationship between these groups suggests that denser and more compacted soils tend to have lower levels of nutrients and organic matter.

The research was conducted as part of the "Ecosytem of Innovation for Next generation Sardinia" (e.INS) project and in synergy with the LOCUST project (funded under the regional law DM 737/2021 of the Sardinia Region). The eINS project targets the dairy sheep farming sector - a crucial component of the Sardinian economy, offering the companies a data-driven tool to identify and fix critical issues in production and processing quickly involving a wide range of field assessments including those related to soil health.

ACKNOWLEDGEMENTS

The activity has been supported by two projects.

Spoke 03 – APPàre: smart and secure livestock farm APPlications to boost data-driven innovation along the food chain, part of "Ecosytem of Innovation for Next generation Sardinia" (e.INS) project funded under the National Recovery and Resilience Plan (PNRR).

LOCUST project: "Studio dei fattori predisponenti le infestazioni acridiche in Sardegna e sviluppo di sistemi di monitoraggio e controllo innovativi e sostenibili", funded under the regional law DM 737/2021, budget 2022-2023, of the Sardinia Region.

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GT 09 - 1035 - P

MICROALGAE-BASED BIOSTIMULANTS: INSIGHTS INTO MECHANISMS OF SOIL ACTIVITY AND EFFICACY ON PLANTS

GT 09. SOIL HEALTH / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Microalgae-based biostimulants represent a promising, sustainable solution for enhancing soil health and promoting plant growth, yet the underlying mechanisms and research directions remain fragmented. In this study, we conducted an analysis to investigate the mechanisms of action of microalgal biostimulants on soil and their efficacy on young plants. Using quantitative and qualitative methods, we systematically reviewed scholarly studies as indexed in Scopus citation database. Our searches targeted studies related to microalgae biostimulatory activity in soil and effects on early plant development and were conducted using terms as occurring in the titles and abstracts (("bio stimul*" OR biostimul*) AND (microalg* OR "micro alg*") AND soil). We identified just under 100 papers which we then classified according to relevance and topics. Visualization software was then used to identify research trends, key thematic areas, and commonly applied phenotypic and physiological assessment methods. The earliest articles retrieved during the search were published in 2010, with a substantial growth of publications from 2019 onwards. 30% of all articles were published in the last year under study (2024). Our findings reveal the dynamic progress of this research field, highlighting dominant topics and methodologies, and uncovering gaps and opportunities for further investigation. When examining the occurrence of terms, we highlight the term fertility, which connects with concepts related to bioremediation, management of natural resources, and impact on plant quality and production. We identified several distinct research directions. For example, one being related to current socio-political terms such as climate change, resilience and food security, and another connected with soil health (polysaccharides, proteins, amino acids, soil enzymatic activity), and biostimulative effect of microalgae on plants.

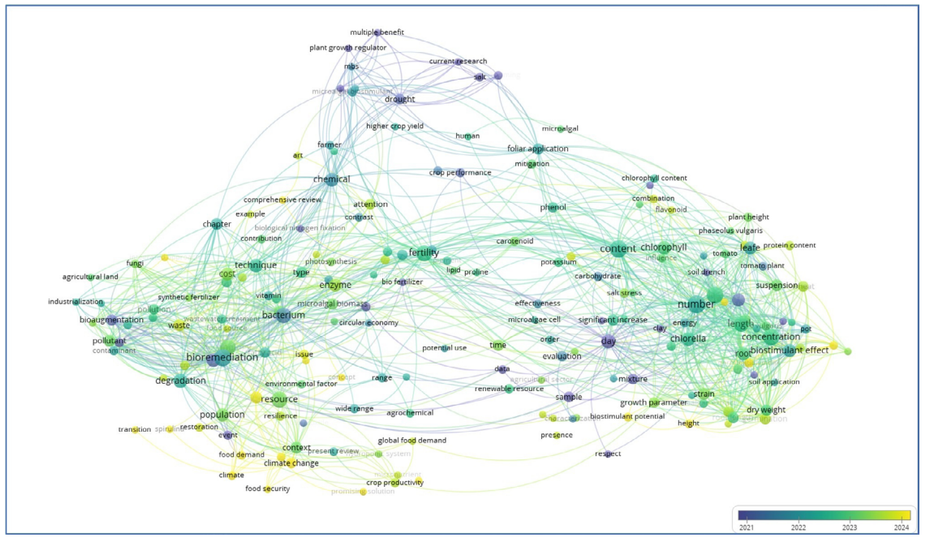


Figure: Temporal network of key terms in research on microalgae biostimulant use in relation to soil health.
Node colors represent the year of term prominence, while edges indicate co-occurrence or conceptual relationships between the terms.
The visualization highlights emerging themes such as sustainability or fertility, in the context of soil health enhancement.



GT 09 - 1069 - P

EFFECTS OF LONG-TERM FERTILIZATION AND CROP ROTATION ON SOIL PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES

GT 09. SOIL HEALTH / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Sustainable agriculture supports soil health and the growth of microorganisms through various management practices. Long-term field trials provide an irreplaceable opportunity to evaluate multidisciplinary relationships between management options and soil properties under real conditions. This multidisciplinary study integrates agrotechnology, agrochemistry, and soil microbiology. A long-term field trial was set up in 1960 in Kuusiku, North-Estonia (58°58'N, 24°42'E, 55 m above sea level). The soil is characterized as Sandy Loam Calcisols (IUSS 2015). Two agrotechnological factors were studied: fertilization (moderate dose of mineral fertilizer (NPK), double dose NPK (NPK2) and moderate dose of mineral fertilizer with farmyard manure (NPK+FM)); and crop rotation (cereal monoculture with spring barley vs. four-field crop rotation).The crop rotation was as follows: potato (Solanum tuberosum)/oil hemp (Cannabis sativa; since 2017); spring barley (Hordeum vulgare); spring barley with under sown red clover (Trifolium pretense); red clover. Field trial was examined, focusing on soil physical (soil bulk density), chemical (pHKCl, P, K, Ca, Mg, Fe, Al, Na, Corg, carbon stock) and biological properties (PLFA content of Gram-positive, Gram-negative bacteria, Actinobacteria and saprotrophic fungi). Fertilization had significant effect to carbon stock in the 0-30 cm layer. The highest carbon stock was observed in the NPK+FM treatment, followed by NPK2, while the lowest was found in the NPK treatment. In contrast, crop rotation had no effect to carbon stock but had significantly affected soil bulk density: cereal monoculture resulted in higher bulk density compared to crop rotation. Fertilization had no significant effect on bulk density. Overall, manure addition together with mineral fertilizer had a positive impact on soil microbial communities across all studied groups. Both mineral fertilizer treatments (NPK and NPK2) showed similarly lower PLFA content, regardless of fertilizer rate. Crop rotation also had a significant positive effect on microbial communities, with cereal monoculture showing markedly lower PLFA values. Crop rotation had minor effect on chemical properties, with only P showing significantly higher values in crop rotation plots. As expected, fertilization significantly influenced all measured chemical parameters except Na. Manure addition significantly increased the values of pHKCl, P, K, Ca, Mg, Corg, and decreased Fe and Al. In conclusion, the results from long-term field trials are stable, indicating permanent equilibrium in the soil and enabling the determination of reliable connections between the measured parameters.

GT 09 - 1079 - P

MONITORING CHANGES ON SOIL ORGANIC CARBON STORAGE AND SOIL HEALTH INDICATORS ASSOCIATED TO CARBON FARMING PROJECTS IN MEDITERRANEAN AGRICULTURAL SYSTEMS

GT 09. SOIL HEALTH / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The central role of soil organic carbon (SOC) for soil multifunctionality encourages the adoption of agricultural and silvopastoral practices enhancing carbon sequestration and storage in soils, and reducing greenhouse gas emissions, i.e., carbon farming practices (CFPs). In addition to the overall positive effects for soil health and climate change mitigation and adaptation, the implementation of CFPs may become an additional source of income for farmers through voluntary C credit markets. The project LILAS4SOILS (Fostering Carbon Farming Practices through LIving LAbS in the Mediterranean & Southern EU for the healthy future of European SOILS), contributes to the overall goal of the European Green Deal and EU Mission "A Soil Deal for Europe" by setting up living labs and enhancing the development of carbon farming projects in the Mediterranean, a region particularly vulnerable to the effects of climate change. The soil and management information that will be collected can also serve the Soil Monitoring Law while taking into account the EU Carbon Removals and Carbon Farming Certification Regulation.

The aim of the soil sampling and monitoring protocol is to provide design-based unbiased estimates of the temporal change in SOC stocks because of CFPs. This soil monitoring protocol will be applied at 85-100 farms (monitored areas ranging between 1-5 ha) located across five living labs and six countries in the Mediterranean (Portugal, Spain, France, Italy, Greece and Israel). Thus, the protocol needs to be flexible and adapted to different agroecosystems (croplands, pastures, vineyards, montado or dehesa, olive groves, etc.), cost-effective, and unbiased. Another objective is to assess the synergies and trade-offs resulting from CFPs in agricultural and agroforestry systems between soil functions. Hence, in addition of SOC stocks and properties needed to assess SOC dynamics with the process-based ARMOSA model, a set of soil health indicators will be measured prior and three years after the start of the carbon farming project: particle size distribution, coarse fragments, bulk density, SOC, total nitrogen, carbonates, pH, potential mineralizable nitrogen, SOC fractions, soil moisture at field water capacity and at permanent wilting point, and 16S rRNA gene amplicon sequencing.

We present the stratified random sampling approaches that will be considered by the living labs, either doing the stratification using environmental covariates, proxies of the drivers of SOC storage at farm scale (soil properties, relief, vegetation and management, mineralogy) that can be easily acquired with remote sensing data, or by stratification using compact geographical strata. The soil sampling approach is also adapted to the particular conditions of dehesa and montado systems (high stoniness, influence of single trees on SOC storage, etc.).



GT 09 - 1082 - P

COMPARISON OF CONVENTIONAL AND NON-CONVENTIONAL INDICATORS FOR SOIL HEALTH MONITORING

GT 09. SOIL HEALTH / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Intensive agriculture, urbanization, water stress, and climate change are affecting Mediterranean soil health by several threats, such as soil erosion, compaction, and soil organic carbon (SOC) loss [1]. Estimating soil health in Mediterranean soils requires key physical and chemical parameters such as SOC content, bulk density, and texture. The organic carbon content is measured by wet oxidation or dry combustion. Bulk density and texture rely on time-consuming methods such as core sampling and hydrometer analysis. These classical laboratory analyses are accurate but time and labour consuming, costly, and use hazardous chemicals, limiting large-scale monitoring.

Sensor technologies offer fast, affordable, and eco-friendly testing. Key proximal sensors include VIS-NIR, FT-NIR, LIBS, pXRF, and gamma-ray attenuation. VIS-NIR spectroscopy (350–2500 nm) accurately predicts SOC and texture (R^2 ~0.75–0.86). FT-NIR provides similar accuracy at reduced costs. LIBS detects elemental signatures with high SOC accuracy (R^2 ~0.83–0.92). Portable XRF indirectly predicts SOC through elemental proxies (R^2 ~0.78). Gamma-ray sensors measure SOC and bulk density precisely under carbonate-free conditions. Satellite and UAV remote sensors provide high spatial and temporal resolution for regional-scale monitoring. Multispectral and hyperspectral imaging maps SOC over large areas but require strong calibration and good surface conditions [2].

Cost, spatial resolution, and precision are the factors in deciding between conventional and sensor-based techniques. Sensor-based methods offer the possibility of higher frequency and resolution with moderate to high accuracy when calibrated, and in an extent perfectly adapted to represent soil surface heterogeneity. VIS-NIR, LIBS, and pXRF sensors are portable, fast, and eco-friendly by considering field limitations (e.g., user bias, water content, coarse material).

Remote sensing provides great coverage but depends on surface conditions and indirect estimation. Conventional methods provide precision but are costly and spatially limited. Blending conventional and sensor data improves accuracy, efficiency, and coverage adapted monitoring for specific parameters of Mediterranean soils threats.

ACKNOWLEDGEMENTS

The SOILS4MED project is part of the PRIMA programme supported by the European Union.

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GT 09 - 1091 - P

REGENERATIVE AGRICULTURE IMPROVES SOIL HYDRAULIC PROPERTIES IN APPLE ORCHARDS

GT 09. SOIL HEALTH / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Regenerative agriculture has been recognized for its potential to enhance soil health and ecosystem services. However, data on its soil hydraulic properties (SHP) impacts remain limited (Lal, 2020; Rhodes, 2017). Field-saturated hydraulic conductivity (Kfs) is a fundamental soil property controlling water infiltration and flow under near-saturated conditions, thereby influencing water and solute transport and groundwater recharge. In perennial agroecosystems (e.g. apple orchards), management practices of the cover crop present in the alleyways profoundly affect soil physical structure and soil health all of which modulate SHP (Ghimire et al., 2022). This study assessed the effects of two alleyways cover crop management practices (Regenerative-R vs Conventional-C) on soil hydraulic properties across an apple orchard located in Lleida, Spain. The regenerative practices were implemented in January 2023 and consisted of a strong reduction in the number of cover crop cuttings and the use of a mower instead of a shredder machine. In addition, pruning was chopped by a pick-up shredder which did not impact the soil. In contrast, conventional management consisted of the use of a regular shredder to both cut the cover crop and to chop pruning. The textural class of the soil orchard was clay. Soil physical attributes (penetration resistance at 0.10 and 0.20 m depth) and SHP (field-saturated hydraulic conductivity – Kfs at 0.10 m depth) were measured in situ in the middle of inter-row. R management significantly increased the percentage of soil covered by plants, improved Kfs and reduced the penetration resistance at both soil depths suggesting better soil structure compared to C. Based on the results, two years after the implementation of regenerative management of the cover crop significantly enhanced soil health, which support earlier findings that regenerative practices can improve soil hydraulic properties especially in upper soil layers. Further long-term, multi-site studies are necessary to fully understand the potential of regenerative agriculture systems to sustain or improve soil health under different agroecological conditions.

ACKNOWLEDGEMENTS

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GT 10. SOIL CARBON DYNAMICS & STABILIZATION

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 10 - 51 - O

SOC ACCUMULATION TRENDS IN LONG-TERM MONOCULTURE POACEAE SWARDS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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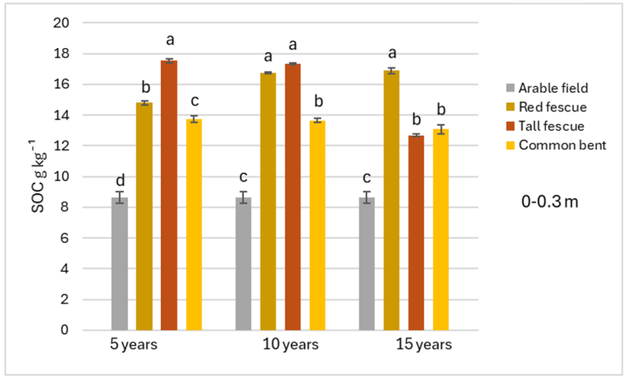
Preserving soil health and its functions is a key goal in many international agreements and national programs to adapt to the intensifying effects of climate change. One recommended strategy to achieve this goal is integrating more perennial plants into agricultural and urban environments. Our study investigated changes in soil organic carbon (SOC) content and grass root biomass at different ages (5, 10, and 15 years) monocomponent swards of Festuca rubra L., Festuca arundinacea Schreb., common Agrostis capillaris L. The results were compared to the annually shallowly ploughed field, with scant soil plant cover for part of the vegetation season data. The experiment site was located at LAMMC in Akademija, Kedainiai district, Lithuania, on a Cambisol (55°23′46.3" N, 23°51′53.4" E). Soil and root samples were taken at 0–0.1 m, 0.1–0.2 m, and 0.2–0.3 m depths in the autumn of 2021 [1]; SOC content was determined using the Nikitin modification of the Tyurin dichromate oxidation method. Significant SOC differences were observed across all studied soil layers in the red fescue swards and ranged from 9.7 to 13.0 g kg^{-1} at a depth of 0.2 to 0.3 m and from 18.2 to 25.0 g kg^{-1} at 0 to 0.1 m. Similar trends, although with some variations, were noted in the swards of other plant species; however, SOC concentrations in these swards were generally lower. While there were fewer significant differences in root biomass across all studied swards due to high variation among replicates, the root mass of red fescue was 1.2 to 4.6 times higher—depending on soil depth and grassland age—compared to tall fescue and common bent. These variations were influenced not only by the specific biological properties of the plants but also by changed botanical composition as the swards aged. Upon assessing the projective field coverage, we found that in the 15-year-old red fescue swards, Poaceae plants accounted for 89.7 % of the coverage, while common bent accounted for only 5.3 %. Similar factors contributed to the variation in the C/N ratio of roots, which is significant for predicting decomposition rates and potential SOC retention in the soil. According to our study results, the C/N ratio of roots in long-term swards increased with swards age. Red fescue demonstrated the highest resistance to forbs and achieved the most significant SOC.

ACKNOWLEDGEMENTS

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SOC content at 0–0.3 m soil depths of different age perennial swards.
AF – arable field, RF—red fescue, TF—tall fescue, CB— common bent.
Note. Significant differences in soil (g kg-1) SOC content are shown at p = 0.05 using letters;
error bars are shown as the standard error (SE) of the mean.

GT 10 - 72 - O

CROP ROTATION AND SEQUENCE OF CROPS IN THE ROTATION INFLUENCE SOIL CARBON AND NITROGEN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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The effect of long-term no-till dryland crop rotations in sequestering C and N in the soil to enhance soil health and environmental quality in arid and semiarid regions needs further exploration. We studied the effect of no-till dryland crop rotations and sequence of crops in the rotation on crop residue C and N inputs and soil total C (STC), soil total N (STN), and NH4-N and NO3-N contents at the 0-120 cm depth from 2012 to 2022 in the US northern Great Plains. Crop rotations and sequences included durum (D) with camelina (C), pea (P) , napus (N), and safflower (S) as well as continuous durum. Residue C was 10-34% greater for DN, DNP, DPS, and DSP; residue N was 19-50% greater for DNP; and residue C/N ratio was 11-20% greater for D than other crop rotations. The STC at 0-15 cm was 10-20% greater for D, DN, and DSP, and at 90-120 and 0-120 cm was 8-19% greater for DS than other crop rotations. The STN at 0-15 cm was 16-19% greater for D and DN than other crop rotations. Soil NH4-N content at 60-120 cm and NO3-N content at 30-60 and 0-120 cm varied with crop rotations and year. Sequence of crops in the rotation did not affect soil C and N. Residue C/N ratio correlated with STC and STN. Increased residue C and N inputs and higher C/N ratio increased STC and STN at the surface soil and crop yield for D, DN, and DSP, but continuous N fertilization and inefficient N uptake by camelina and napus increased NO3-N content at surface and subsurface soils for DPN and DC,.

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We sincerely acknowledge the assistance provided by Michael Johnson, Mark Gaffri, Wayne Adkins, Rene France, Margaret Duffy, and Chloe Turner-Messervy in field operations, managing plots, and collecting soil and plant samples and for Margaret Duffy and Chloe Turner-Messery for preparing and analyzing soil and plant samples in the laboratory.

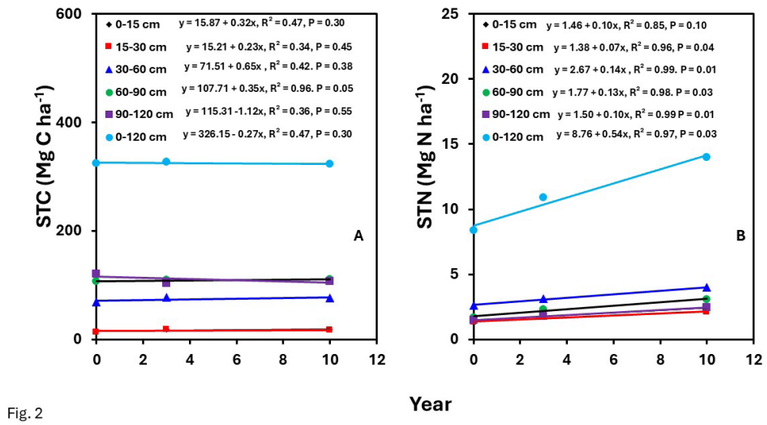


Fig. 2



GT 10 - 75 - O

MONITORING UPTAKE OF ROOT-DERIVED CARBON INTO THE SOIL CARBON POOL AND MICROBIAL COMMUNITY USING STABLE ISOTOPE PROBING OF VOLATILE ORGANIC COMPOUNDS (SIP-VOC) AND SIP-PLFA ANALYSIS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Root decomposition derived compounds are believed to constitute a significant source of soil organic matter [1]. Organic exudates from plant roots, and their subsequent utilisation by soil microbial communities, plays a critical role in terrestrial carbon fluxes. Different agricultural management practices can induce different modes of root senescence, which will directly or indirectly alter factors that affect the rates of root decomposition and the quantity and rates of carbon entering and being retained in the soil. Living roots can produce a wide range of volatile organic compounds (VOCs), especially when the roots are damaged [2]. This study aims to trace the fate of root-derived carbon into the soil carbon pool by utilising SIP-VOC to characterise temporal changes to metabolic activity and the degradation of labile organic forms during root senescence, combined with next-generation genomics sequencing to create a snapshot of soil microbial communities, and SIP-PLFA analysis to track the incorporation of 13C-enriched root material into the soil microbial community. The results indicate that different agricultural management practices can induce distinct volatile profiles, with the temporal effect being more pronounced. The composition of actively decomposing microbes varies depending on time and the extent of root disturbance caused by agricultural management practices. Over the long-term, reduced root disturbance dramatically increases carbon incorporation by soil microorganisms.

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GT 10 - 90 - O

THE INFLUENCE OF DIFFERENT EUROPEAN TREE SPECIES ON THE STABILIZATION OF SOIL ORGANIC MATTER

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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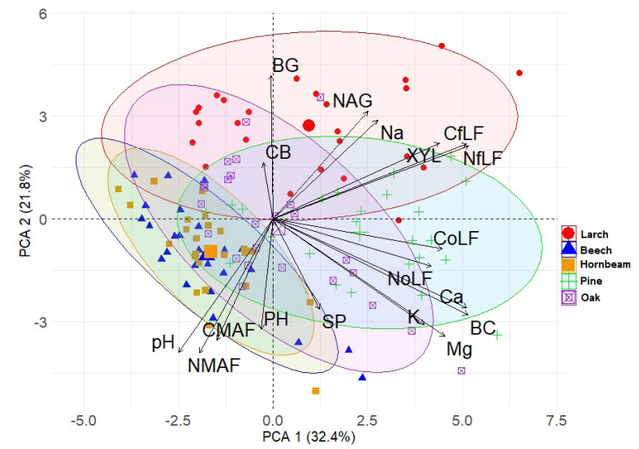
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The species composition of forest stands plays an important role in shaping the properties of forest soils. Therefore, in the face of the threat of weather anomalies, it is important to strive to improve the stability of forest ecosystems by changing the species composition of forest stands. To date, a number of studies have been devoted to the impact of trees on the forest ecosystem, especially on the soil environment through the addition of above-ground biomass. However, there is not enough knowledge about the impact of root system characteristics on forest soil properties and biodiversity. Tree species through aboveground biomass and roots are a key factors influencing the quality and quantity of soil organic matter. Our study aimed to determine the stability of soil organic matter in Luvisols under the influence of five different tree species. The study areas were located 25 km north of Krakow, in southern Poland. The study included five tree species - Scots pine (Pinus sylvestris L.), European larch (Larix deciduas Mill.), pedunculate oak (Quercus robur L.), beech (Fagus sylvatica L.) and hornbeam (Carpinus betulus L.). Forest stands growing in the same soil conditions (Luvisols) with similar geological material (loess) and grain size were selected for the study. We evaluated labile and heavy fractions of soil organic matter (SOM). Additionally, basic physicochemical properties (pH, carbon and nitrogen content, base cation content) were determined in soil samples. The results of our study showed that soils under the influence of coniferous species were characterized by a higher content of carbon of free light fraction (CfLF) and carbon of occluded light fraction (CoLF) compared to deciduous species. Similar relationships were found with the nitrogen content of the free light fraction (NfLF) and nitrogen of occluded light fraction (NoLF). Higher CMAF and NMAF contents were recorded in soils influenced by deciduous species. The carbon, nitrogen and base cations content positively correlated with the C and N of free light fraction and occluded light fraction. PCA analysis confirmed the connection of C and N of heavy fractions (CMAF and NMAF) with deciduous species. Our research shows that avoiding single-species conifer stands and introducing admixtures of deciduous species, which increase SOM, is justified in forest management. The selection of suitable species will provide greater stand stability and contribute more to the carbon accumulation in the soil.

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Projection of variables onto the plane of the first and second PCA factors (pH, Ca, K, Mg, Na BC-sum of cations (cmol(+)·kg-1); CB—ß-D-cellobiosidase,, BG—ß-glucosidase, NAG—N-acetyl-ß-D-glucosaminidase, XYL—ß-xylosidase, PH—phosphatase, SP – arylsulphatase; CfLF - carbon of free light fraction (g.kg-1), CoLF – carbon of occluded light fraction (g.kg-1), CMAF – carbon of mineral associated fraction (g.kg-1), stands (NfLF - nitrogen of free light fraction (g.kg-1), NoLF – nitrogen of occluded light fraction (g.kg-1), NMAF – nitrogen of mineral associated fraction (g.kg-1))



GT 10 - 91 - O

EFFECTS OF WARMING ON SOIL CARBON STORAGE AND SOIL STRUCTURAL STABILITY – A CASE STUDY FROM THE TASMANIAN HIGHLANDS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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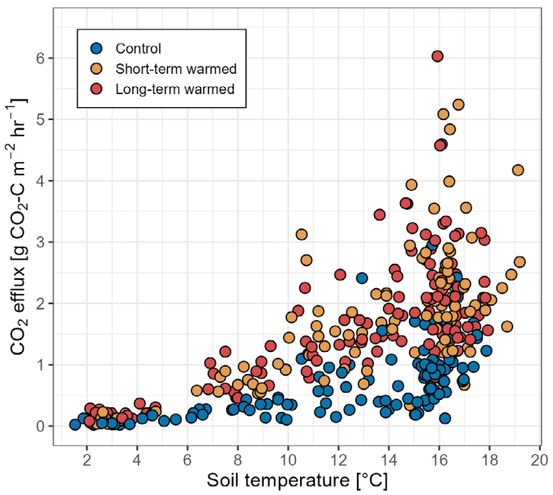
Large parts of the Central Highlands of Tasmania feature highly organic soils that store significant amounts of carbon (C) and provide a key ecosystem service in terms of water capture, storage and filtration. However, their status as carbon sinks is threatened by climate change, as the soil carbon cycle is strongly influenced by already occurring shifts in temperature and soil moisture. Understanding how warming influences soil carbon dynamics is therefore essential for ensuring appropriate management in a changing climate and, ultimately, the conservation of the unique highland ecosystems supported by organic soils.

Previous results from this system have shown that ecosystem respiration measured in the field was substantially increased by warming. This research combined measurements from long-term field experiments with laboratory methods to explore how warming influences soil stability and soil organic carbon (SOC) storage, leading to the question: Could warming-induced changes in soil structure have influenced SOC accessibility and in turn, respiration rates?

Measurements and soil were collected from a long-term (~10 years) passive warming experiment located in the Tasmanian Central Highlands (900 m.a.s.l), where open-top chambers were used to achieve a warming of approximately 2°C above ambient. The addition of new chambers in 2022 allowed exploration of responses to both short- and long-term warming.

Monthly field measurements confirmed that ecosystem respiration rates measured as CO2 efflux in situ were consistently higher throughout the year in both short- and long-term warmed plots than in control plots. Analysis of soil samples clearly demonstrates no evidence of soil structural degradation measured as abundance and size distribution of water-stable aggregates and no evidence of SOC depletion in response to warming. This result suggests that the increased CO2 efflux was either offset by a proportional increase in C input to the SOC pool or that warming primarily affected plant respiration rates.

The results of this study are important for understanding the driving forces behind SOC stability and consequently, the vulnerability of Tasmanian highland organic soils to climate change-induced warming. Future research should examine plant growth and C intake in response to warming and investigate the link between extreme moisture conditions and C dynamics.



Soil temperature and ecosystem CO2 efflux measured monthly for 12 months from an experimental warming site in the Central Highlands of Tasmania.

GT 10 - 107 - O

SOIL CARBON AND NITROGEN DYNAMICS IN REWILDED EUROPEAN LANDS: INSIGHTS FROM META-ANALYSIS AND ISOTOPIC TRACERS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Rewilding abandoned lands is a cost-effective passive approach to facilitate long-term sequestration of carbon (C) and climate change mitigation. Following land abandonment, natural restoration driven by succession and microbial processes can recover soil organic carbon (SOC) pools and improve ecosystem resilience progressively. Through a systematic review of 36 European studies (e.g., [1], [2], [3], etc.), we explored SOC sequestration after land abandonment relative to key environmental factors including, soil group, forest type, land aspect/exposition, and former land management. Interestingly, SOC sequestration was highly significant in the Mediterranean region, specific soil groups (Cambisols, Regosols, and Caclisols), cropland-converted broadleaf and mixed forests, and some expositions (North, South, and Southwest-facing sites). In addition to this meta-analysis, empirical findings from depth-specific $\delta^{13}C$ and $\delta^{15}N$ profiles and Bayesian stable isotope mixing models in the Bohemian Karst chronosequence, Czech Republic, suggest that some rewilded sites underwent a pronounced shift between C4/C3 plants. Moreover, time since abandonment—soil $\delta^{15}N$ signature relationship along the chronosequence revealed transitions from open to closed nitrogen (N) cycles. Increases in SOC and TN stocks, along with isotopic evidence, reveal a successful rewilding strategy that improves carbon storage as well as N retention and thus stabilization of abandoned agroecosystems over time.

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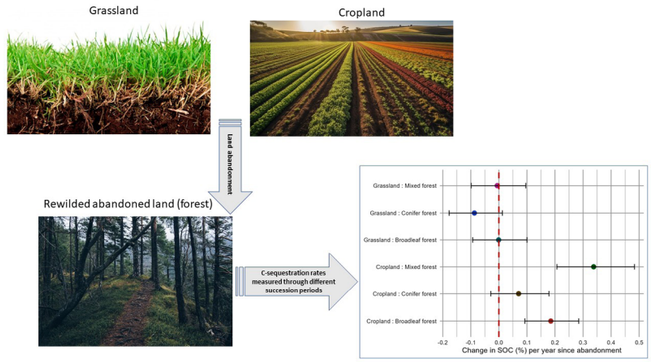
We used the free images designed by Freepik to create the graphical abstract (image).

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GT 10 - 112 - O

THE EFFECT OF SPONTANEOUS COVER CROP AND ORGANIC MANAGEMENT ON SOIL CARBON STOCK AND SOIL ORGANIC CARBON FRACTIONS IN POMELO ORCHARD IN TAIWAN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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This study aimed to evaluate the effect of soil management (spontaneous cover crop and organic management) on soil organic carbon (SOC) storage and carbon fractions in pomelo orchards. The research was carried out in Madou and Douliu in Taiwan. The investigation focused on the impact of spontaneous cover crop, pruned branch mulching, and organic management on soil organic carbon storage, carbon fractions and crop productivity. Results showed that orchards implementing spontaneous cover crop and branch return had an average SOC stock of 48–50 tons per hectare (0–30 cm depth), approximately 86% higher than those without such practices (around 26.2 t/ha). The TOC400 (labile carbon oxidized below 400°C) was the dominant carbon type, which also showed a moderate positive correlation with soil aggregate stability. Although SOC stocks did not differ significantly between organic and conventional orchards, the widespread emphasis on organic matter management among farmers was identified as a key factor in improving soil quality. These findings supported the spontaneous cover crop and branch return as an effective strategies for enhancing soil carbon storage and for sustainable agricultural management.

ACKNOWLEDGEMENTS

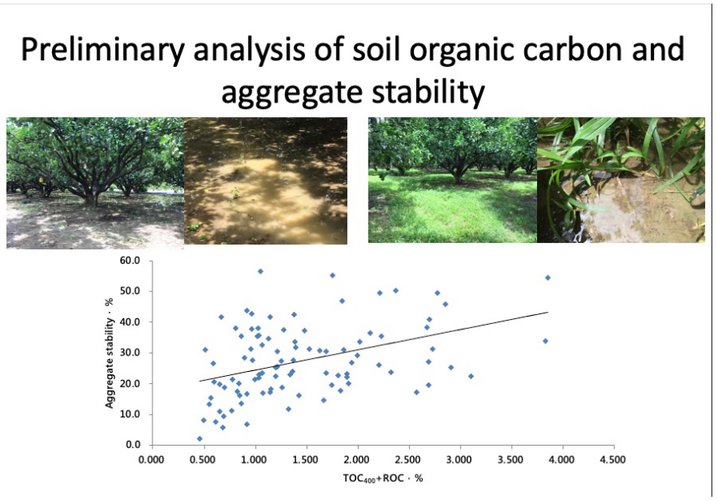
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GT 10 - 137 - O

LINKING CROP DIVERSIFICATION TO SOIL MICROBIAL DECOMPOSITION AND ORGANIC CARBON STORAGE – SYNTHESIS OF THE PAN-EUROPEAN EJP SOIL PROJECT ENERGYLINK

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Crop diversification is regarded as a promising agricultural practice for enhancing soil organic carbon (SOC) storage, and it is actively promoted by the EU Common Agricultural Policy. It remains, however, unclear through which mechanisms diversified cropping systems influence SOC accumulation. The EJP Soil EnergyLink project aimed to elucidate the relationship between crop diversification and SOC stabilization across a pan-European pedo-climatic gradient. Specifically, we investigated whether increased above-ground crop diversity influences microbial compositional and functional diversity, carbon use efficiency (CUE), and necromass formation as well as organic matter stocks, stoichiometry, and chemical diversity. This research was driven by the notion that microbial-derived SOC constitutes a significant fraction of stabilized SOC, particularly through the so called in-vivo pathway of SOC stabilization. We hypothesized that greater crop diversity would enhance microbial diversity and CUE, leading to greater SOC stabilisation.

To test this hypothesis, we collected soil samples from eight field sites across Northern to Southern Europe: Sweden, Lithuania, Netherlands, Czech Republic, Austria, France, Slovenia, and Spain. The diversification strategies included cover cropping, ley farming, and the integration of vegetation strips into perennial cropping systems, representing common European agricultural practices.

Contrary to our initial hypothesis, our findings revealed that crop diversification had no consistent impact on SOC storage, molecular diversity of organic matter, or microbial CUE in bulk soils. Additionally, increased plant diversity did not translate into greater microbial compositional or functional diversity. However, we observed that the introduction of vegetation strips in perennial cropping systems lead to increased SOC, molecular diversity, and fungal richness. Interestingly, these changes did not affect microbial CUE, as microbial growth and respiration increased proportionally. Our results suggest that in perennial cropping systems, SOC accumulation is driven by the quantity of organic matter inputs, the acceleration of microbial turnover, and the contribution of necromass to SOC. Furthermore, while our data did not indicate broad-scale shifts in microbial pathways of SOC stabilization, changes in microbial parameters and necromass contribution to SOC point to the importance of the in vivo pathway. This suggests that microbial growth, biomass, and turnover—rather than microbial CUE—may be the primary drivers of microbial-derived SOC stabilization. Future research should further



explore these mechanisms to refine our understanding of SOC dynamics in diversified cropping systems.

ACKNOWLEDGEMENTS

This work was supported by European Union's Horizon 2020 research and innovation programme (grant number 862695).

GT 10 - 152 - O

EFFECT OF LONG-TERM INCORPORATION OF CROP RESIDUES AND CONSERVATION TILLAGE ON SOIL ORGANIC CARBON STOCKS IN A MEDITERRANEAN FARMLAND UNDER DESERTIFICATION RISK: A 13C STUDY.

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Increasing soil organic carbon (SOC) content is a key goal for improving soil quality and hence adaptive capacity to climate change contributing to Agenda 2030 for Sustainable Development [1, 2]. Such task becomes vital and challenging in areas already fragile and prone to degradation such as drylands. With special reference to agricultural drylands, the selection of a sustainable management practices (SMPs) is crucial to prevent an intensification of degradation processes already on and hence to sustain food production and strengthen their role in the global carbon cycle and climate regulation. The combination of occasional tillage with pruning residues as mulch is increasing adopted as SPM to foster SOC sequestration in arid and semi-arid agroecosystems [3]. As highlighted by Lavallee et al. [4], it is crucial to assess the different contribution of soil organic matter (SOM) fractions, i.e. particulate (POM) and mineral associated organic matter (MAOM), in order to increase its stabilization over the long term. Our study aims to evaluate the effect of 10-years incorporation of two different prickly pear (Opuntia ficus-indica (L.) Mill.) crop residues inputs in combination with occasional tillage on soil organic carbon stock changes in the topsoil (0-30 cm) of a Mediterranean farmland under desertification risk, with special reference to the SOM distribution into POM and MAOM fractions. The long term incorporation of Opuntia residues (C4-C source) into native C3-SOC soil was assessed by δ13C signal and calculated by using the mass balance equation suggested by del Galdo et al. [5].

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GT 10 - 159 - O

FIRST SIGNS THAT NATIONAL CROPLAND ORGANIC CARBON LOSS IS REVERSING IN BRITISH TOPSOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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High historic rates of soil organic carbon (SOC) loss from cropland soils are well known, contributing to climate change and compromising soil and ecosystem health. Stabilizing and reversing the loss of organic matter from cropland soils is a challenge for all nations to meet under the United Nations Sustainable Development Goals, including for sustainable food production. Sustainable land management (SLM) has been promoted as a mechanism of achieving this, but to date, there is no evidence of positive impacts at scale. Here we show the first signs of the reversal of soil carbon loss in cropland topsoils in Great Britain, following a period of reported SLM uptake, using 40+ years of national soil monitoring from the UKCEH Countryside Survey. Following a prolonged historic decline at rates of -0.16 t ha-1 yr-1 from 1978 to 2007, there was a significant increase in cropland topsoil SOC stocks (0-15 cm) from 2007 to 2019-22 with an accrual rate of 0.17 t ha-1 yr-1, approximately 0.74 MtC yr -1 nationally. Both carbon concentration and stock increase over this period, alongside a significant reduction in bulk density. The drivers of this change have not been established, and will likely be challenging, in part because management data at the scale of the national monitoring program is not available, despite coinciding with a period of reported SLM uptake. The increase in topsoil SOC could represent net carbon sequestration or carbon redistribution (geographic or vertical) but nevertheless demonstrates that topsoil properties that support soil health can be restored at scale and offers hope that a concerted effort by land managers may be halting, and reversing, SOC loss from cropland soils.

GT 10 - 175 - O

ENHANCING SOC MODEL PERFORMANCE FOR CARBON FARMING USING LONG-TERM EXPERIMENTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Carbon farming (CF) practices play an essential role in enhancing soil organic carbon (SOC) sequestration, but their implementation requires accurate and credible monitoring, reporting, and verification (MRV). Long-term experiments (LTEs) can serve as benchmark sites in MRV frameworks to assess SOC changes via CF practices and test models [1]. SOC models complement monitoring efforts by projecting SOC changes under various climate and management scenarios, supporting model evaluation at benchmark sites and replicability across different scales.

In this study, we used three LTEs in Denmark. CENTS and Askov, with historical SOC data, were used to test and calibrate the C-TOOL [2] and RothC [3] models under different CF practices: straw removal/retention (-/+straw) at CENTS, and grassland conversion with unfertilized (UNF) and NPK fertilization at Askov. The models were then applied to the BRAK experiment, comprising similar CF practices but lacking historical SOC data, to forecast SOC changes. Models were initialized using historical data (e.g., initial SOC), while default parameters were used for pool fractions and other model-specific settings. Global sensitivity analysis (SA) using the Morris method [4] identified influential parameters for future calibration.

At CENTS, measured SOC slightly declined under -straw and increased under +straw rotations since 2002, with C-TOOL performing slightly better for +straw and RothC for -straw (Figure 1a). At Askov, C-TOOL closely matched observations in UNF treatment, whereas RothC significantly underestimated SOC during the arable phase (1923-1987) but captured the increasing trend in the grassland phase. For NPK, RothC produced more consistent results across both phases, whereas C-TOOL tended to overestimate SOC in the arable phase and underestimate it under grassland (Figure 1b). In BRAK, both models projected SOC increases under +straw, with significantly larger SOC accumulation in RothC. Under -straw, RothC predicted a significant SOC increase, especially in the grassland phase (2022–2035), while C-TOOL showed virtually no SOC change (Figure 1c). Morris SA identified initial SOC, the humified pool fraction, and its decomposition rate constant as most influential parameters.

Initial simulations using default values resulted in notably different SOC predictions between models at BRAK. This divergence highlights the need for targeted calibration, especially when models support MRV frameworks or C trading schemes, where reliable SOC estimates are essential. SA provides a basis for improving model accuracy by identifying key parameters for adjustment, supporting credible CF assessments.

KEYWORDS:

SOC model, C-TOOL, RothC

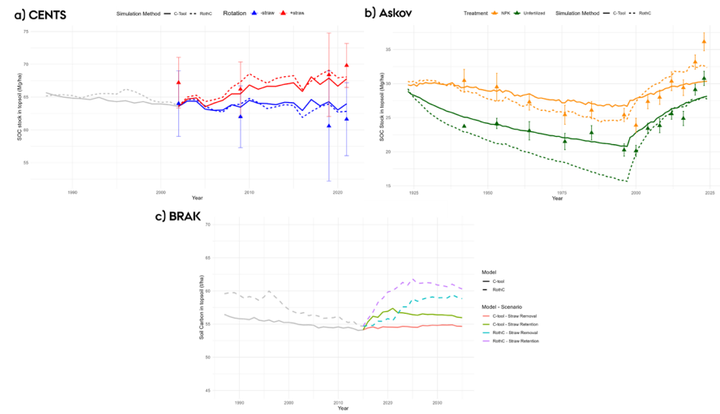
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Initial simulation results with default parameters.

GT 10 - 176 - O

THE QUALITY OF ORGANIC MATTER INPUT AFFECTS THE DECOMPOSITION OF SOC: EVIDENCE FROM A C3-TO-C4 CONVERSION EXPERIMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Assessing the long-term effects of agricultural practices on soil organic carbon (SOC) dynamics is essential, as even minor changes in SOC stock can influence atmospheric CO2. In this context, long-term field experiments are an important source of information on the effect of specific managements on SOC storage, including the role of annual incorporation of crop residues and animal manures. However, conventional experiments often overlook how added C inputs affect both retention and the turnover of existing SOC.To address this gap, we used soils from a long-term experiment (1996–2023) with outdoor concrete cylinders located at Askov Experimental Station (Denmark). Silage maize was grown every year on a sandy loam soil with a C3-crop prehistory and subjected to different C4-derived organic matter inputs: maize root and stubble only (M), M+0.8 kg DM m-2 of aboveground maize biomass (M+MB), M+0.8 kg DM m-2 of maize derived sheep faeces (M+MF) (Figure 1).At the final sampling in 2023, C4-SOC from maize stubbles and roots accounted for 32% of the total-SOC. When soil was amended with additional inputs of maize biomass and sheep faeces, total-SOC increased and C from these C4-sources averaged 50% and 63%, respectively. Over a 27-year period, the soils retained about 10% and 19% of the total C4-C added in aboveground maize biomass and maize derived sheep faeces, respectively. Notably, the addition of sheep faeces resulted in a greater loss of C3-SOC (55%) compared to a similar C input from plant biomass (47%).Our result suggest that organic matter inputs of different biological quality may lead to different losses of C3-SOC.

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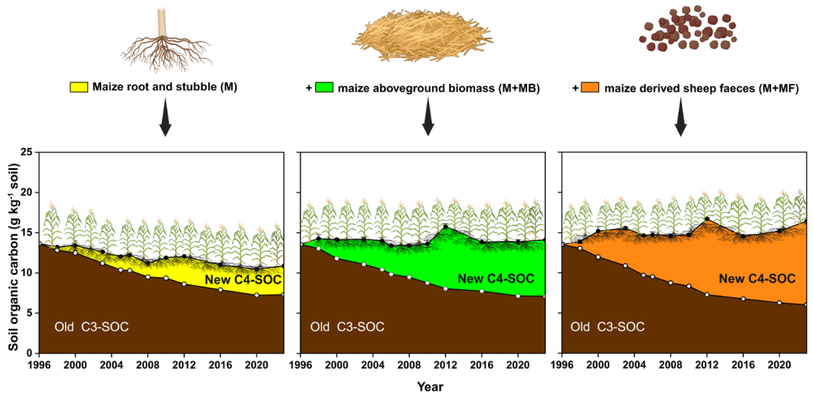


Figure 1. Accumulation of C4-SOC in soil previously dominated by C3 plants over 27 years with different C4-derived organic matter inputs: maize root and stubble only, M+0.8 kg DM m-2 of aboveground maize biomass, M+0.8 kg DM m-2 of maize derived sheep faeces.

GT 10 - 204 - O

SPATIAL VARIABILITY OF SOIL ORGANIC CARBON AND NITROGEN FRACTIONS UNDER DIFFERENT VEGETATION COVERS AND TOPOGRAPHY IN ILMOTIOK RANCH, KENYA

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Understanding the influence of topography and vegetation cover on soil carbon and nitrogen stocks is critical for informing land restoration and sustainable management in dryland ecosystems. This study assessed the spatial distribution and variation of soil organic carbon (SOC), particulate organic carbon (POC), mineral-associated organic carbon (MAOC), and soil organic nitrogen (SON) in relation to slope position, vegetation cover, and soil depth in Ilmotiok Community Ranch, Laikipia County, Kenya. A stratified sampling approach was employed across three topographic zones—upper, mid, and lower slopes—combined with dominant vegetation types: bare ground, grasslands, shrubs, and trees. Soil samples were collected from two depth intervals (0–15 cm and 15–30 cm) during the long and short rainy seasons of 2016 and analyzed using standard laboratory protocols. Statistical analyses confirmed significant main effects ($p < 0.05$) of slope position, vegetation cover, and soil depth on all measured variables, with notable interactions between slope and vegetation. The results revealed that SOC stocks ranged from 6.0 to 23.4 Mg C ha^{-1}, with significantly higher values in toe slope positions and under tree and shrub cover compared to bare and grass-covered areas. MAOC represented the dominant carbon fraction, contributing 62–77% of total SOC, while POC varied from 2.3 to 8.6 Mg C ha^{-1} and was highest in the upper 0–15 cm layer. SON stocks ranged from 1.5 to 4.8 Mg N ha^{-1}. These findings underscore the critical role of vegetation restoration and slope position in enhancing soil carbon and nitrogen sequestration.

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Table 5. Interaction of Zone and Depth on SOC and SON Stocks (Mg/ha)

Zone	Depth (cm)	SOC (Mg/ha)	POC (Mg/ha)	MAOC (Mg/ha)	SON (Mg/ha)
Toe Slope	0–20	7.89[a]	4.73[a]	3.16[c]	0.82[a]
	20–50	4.95[b]	1.73[b]	3.22[a]	0.53[b]
Mid Slope	0–20	7.71[a]	4.63[a]	3.08[c]	0.80[a]
	20–50	4.89[b]	1.71[b]	3.18[a]	0.52[b]
Foot Slope	0–20	6.86[c]	4.12[c]	2.74[d]	0.72[c]
	20–50	4.59[d]	1.62[c]	2.97[b]	0.49[c]

Letters a, b, c denotes statistical significance notation. Different letters indicate statistically significant differences ($p < 0.05$) among means.



GT 10 - 223 - O

DIFFERENCES IN SOIL ORGANIC CARBON AND PLANT PROPERTIES AMONG AGRICULTURAL LAND TYPES USING REAL-TIME NEAR-INFRARED SPECTROSCOPY

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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New mobile near-infrared spectroscopy (NIRS) technology allows more frequent nutrient analysis of soil and plant properties among farms and agricultural land uses in real-time. The aim of this study was to assess soil organic carbon (SOC) and plant properties among different types of agricultural land. A total of 101 fields of either arable, temporary ley or permanent grassland were studied across five farms in spring 2023 and 2024 in the UK. The study collected 505 soil and 505 plant samples from the same location, with nutrients analysed using NIRS. A linear mixed model was used to assess differences among land types. The main soil and plant properties assessed were soil depth, SOC (g/kg, tonnes/ha, ratios with nitrogen, clay and plant organic carbon (POC)), plant height, biomass cover and common plant nutrients. Among the land types studied, the majority of soil samples from permanent grassland had very good SOC/clay ratio, whereas arable and temporary ley samples were predominantly of good or moderate levels. Regional differences were found in soil depth (cm), SOC stock (t/ha) and SOC/clay ratio. A negative correlation between SOC/POC ratio and plant biomass properties (height (cm) and both fresh and dry covers (t/ha)) were observed. The mobile NIRS analysis can aid large scale monitoring of both soil and plant nutrients, with more frequent measurements helping landowners manage organic carbon stocks.

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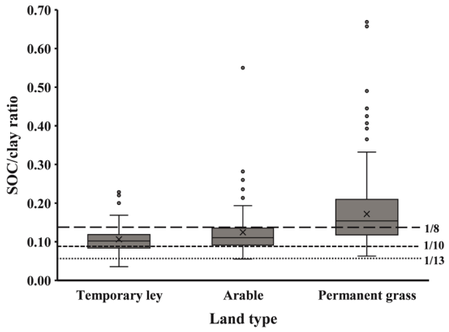


Figure 1: Box and whisker plot of SOC/clay ratios for each soil sample from temporary ley, arable and permanent grass fields across farms studied. The mean value is indicated by 'X', median by the solid line in each box, lower edge of the box is the lower quartile and the upper edge of the box is the upper quartile, with the minimum and maximum values represented by the whisker and dots are outlier values. The long-dashed line indicates the SOC/clay ratio category of very good (> 1/8), the short-dashed line is good (> 1/10), the dotted line presents moderate (> 1/13) and degraded (< 1/13).

GT 10 - 227 - O

INVESTIGATING THE INTERACTIONS AMONG SOIL CARBON, MICROBIAL DIVERSITY, AND LAND-USE MANAGEMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 04. SOIL BIOLOGY

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Deciphering the complex relationships among soil organic matter (SOM), microbial diversity, and land-use decisions is essential for maintaining soil health and addressing climate change. The field of SOM biogeography—focused on how SOM varies across landscapes—offers key insights into how SOM fractions relate to soil microbial and mesofaunal communities, which are foundational to soil function.

Because soil carbon dynamics can influence global warming through feedback mechanisms, a deeper understanding of how SOM pools interact with biological processes is crucial. Such knowledge is fundamental to maintaining ecosystem services like soil productivity and long-term carbon storage.

Despite the central role of microbial biodiversity in soil fertility and carbon sequestration, the drivers shaping these communities over large geographic areas remain insufficiently characterized. At the same time, changes in land use have degraded soil health and SOM levels, negatively impacting both natural and managed ecosystems. Recognizing that soil microbes are key regulators of the carbon cycle, this study examined how land-use practices and environmental gradients affect soil biodiversity.

By integrating extensive datasets on soil biology, climate, and landscape features, this research conducted a large-scale analysis to inform sustainable land management. The study mapped patterns in microbial diversity and richness, identifying key environmental and land-use factors that influence them. It further explored how bacterial, fungal, and mycorrhizal communities co-vary with soil functions—such as enzyme activity—and the presence of genes involved in carbon cycling. By connecting these biological indicators to SOM composition, land use, and pedo-climatic conditions, the research provides a strong foundation for enhancing soil conservation and climate-resilient agriculture.



Soil Carbon team FRDC



GT 10 - 236 - O

LONG-TERM SOIL CARBON LOSS AND GREENHOUSE GAS IMPACTS FROM FOREST CONVERSION TO AGRICULTURE IN MEDITERRANEAN SPAIN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Deforestation to enable agricultural expansion remains one of the most significant land-use changes globally, with approximately 40% of Earth's surface now dedicated to food production. In Spain, widespread deforestation occurred between 1940 and 1960, driven by international isolation policies that increased demand for timber and arable land. A representative case is the Mediterranean "Bosque de Matasnos" (Peñaranda de Duero, Spain), where 149 hectares were partially cleared in 1960 for cereal and vineyard production (Figure 1). Since 2009, both cropping systems have adopted sustainable practices, including crop rotation (cereal) and organic amendments (vineyard). This study evaluates the long-term impacts of forest conversion to cereal or vineyard systems on soil carbon (C) and nitrogen (N) stocks and greenhouse gas (GHG) emissions (N_2O and CH_4). Soil C stocks were quantified at two depths (0–20 cm and 20–40 cm) across land uses (forest, cereal, vineyard), while GHG fluxes biweekly monitored over the course of one year. Results show that forest soils retained the highest organic C content, followed by cereal and vineyard systems, with surface layers (0–20 cm) consistently richer in C than subsurface layers. N stocks were similar across land uses, though cereal fields exhibited slightly higher surface N accumulation. Agricultural systems significantly reduced the soil's capacity to act as a CH_4 sink, while N_2O emissions remained low (<500 g N_2O-N ha^{-1} yr^{-1}) and did not differ significantly among land uses. These findings highlight the persistent C stock depletion caused by historical deforestation, underscoring the limited recovery of soil organic matter even under sustainable management.

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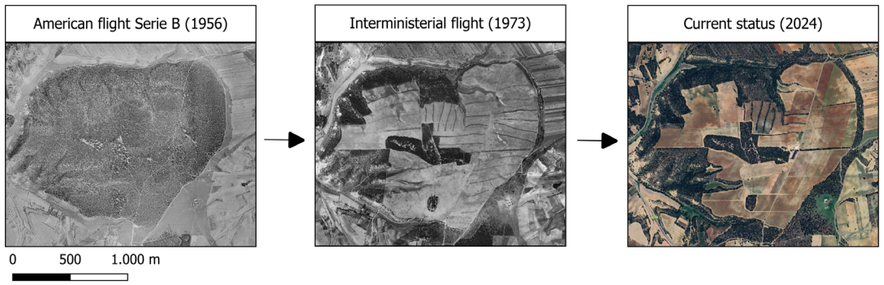


Figure 1. Transition from Forest (1956) to Cereal Crops (1973) and Vineyards (2024) Over the Years

GT 10 - 248 - O

DECADAL DECLINE IN FOREST FLOOR SOIL ORGANIC CARBON AFTER CLEAR-CUTTING IN NORDIC AND CANADIAN FORESTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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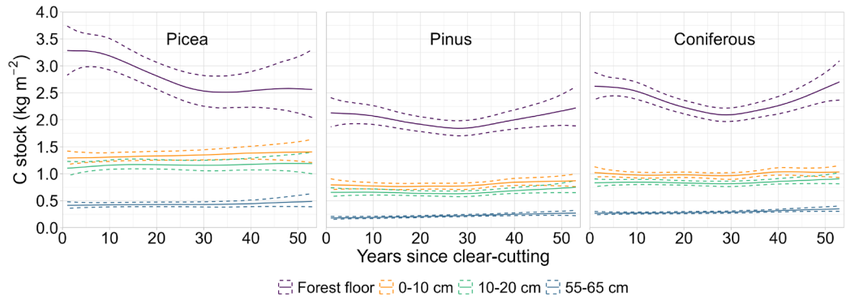
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Nearly half of global terrestrial carbon (C) is stored in forests, and temperate and boreal forests store 50–90% of total ecosystem C in soils. In the Nordics and Canada, forests are largely managed in a silvicultural system with clear-cut harvest. While several meta-analyses have investigated the effect of forest harvesting on soil C storage, these have often been heavily based on data from temperate forests, and tend to pool thinning and clear-cut harvests. Thus, knowledge gaps still remain in terms of how clear-cut harvest affect soil C storage in boreal and northern temperate forests. To alleviate this knowledge gap, we harmonized National Forest Soil Inventory (NFSI) data from Sweden, Finland, Norway, Denmark, and Canada, and used a space-for-time approach to examine soil C storage dynamics up to 53 years after clear-cut harvest. We found that forest floor C storage in all coniferous stands declined continuously for ~30 years after clear-cutting, but C storages in 0–10 cm and 10–20 cm mineral soil layers were stable throughout the 53 years. Compared to forests dominated by Pinus species, forests dominated by Picea species had larger initial C storages in all examined soil layers, lost larger amounts of forest floor C, and did not show signs of forest floor C recovery within the examined 53 years. When at its lowest level, ~30 years post clear-cut harvest, forest floor C storage in Picea and Pinus dominated forests had decreased by 23% and 14% relative to initial levels, respectively. In contrast to Picea dominated forests, forest floor C in forests dominated by Pinus species recovered to pre-harvest levels 48 years after clear-cutting. In short, our results shows that clear-cut harvest has substantial and long-lasting effects on northern temperate and boreal forest soil C storage, and that combining data from several NFSIs can help elucidate forest management effects on soil C storage.

ACKNOWLEDGEMENTS

The work was carried out in the context of and with support from the annual Nordic Forest Research (SNS) network "Integrating Soil Monitoring in Nordic Forests – data harmonization, future designs and studies to examine soil function at different scales" (NorForSoil, project N2023-05) with country-specific in-kind contributions from the authors' organizations. CFJ, JN, KSL and HS acknowledge funding from the Research Council of Norway, Contract No. 342631/L10, the research project (ForBioFunCtioN, Research Council of Norway, grant number 303006, with JN as grant holder), and CFJ, JN and HS additionally acknowledge funding from the Norwegian Institute for Nature Research (NINA). AL acknowledges funding from the European Union's Horizon 2020 program (no. 101000289) project HoliSoils – Holistic management practices, modelling, and monitoring for European forest soils.



GT 10 - 261 - O

IMPROVED SOIL STRUCTURE ALONG A GRADIENT OF SOIL ORGANIC CARBON CONTENT IDENTIFIED AS THE MAIN DRIVER OF YIELD AND YIELD STABILITY RESPONSES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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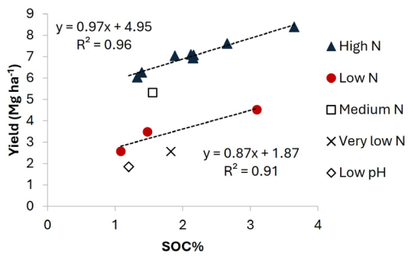
Adopting agricultural practices that promote the accumulation of soil organic carbon (SOC) can offer a win-win strategy—helping to mitigate global warming while enhancing soil fertility and resource use efficiency. However, the mechanisms by which SOC influences crop productivity and yield stability are complex and often interrelated, making them challenging to isolate. To disentangle these mechanisms, we analysed silage maize yield responses over a 20-year period (2000–2019) in relation to SOC contents across 14 experimental treatments within a long-term field trial at Ultuna, Sweden. The site is characterized by a cold temperate and subhumid climate with an annual mean air temperature of 5.8 oC and an annual mean total precipitation of 542 mm. Established in 1956, this trial encompasses a wide range of SOC levels in the topsoil (0–20 cm), from 0.94% to 3.65%. In our previous work [1], we separated the effects of soil acidity, N availability and dry soil bulk density (as a proxy for soil structure), which explained 95% of the variation in silage maize yield among treatments. It was also shown that approximately two-thirds of the yield increase associated with SOC was attributable to improvements in soil physical properties. We now expanded our analysis on the dataset considering the effect of inter-annual variations in weather conditions during the growing seasons by including the aridity index (the ratio of potential evapotranspiration over total precipitation). The mean growing season aridity index over the 20-year period was 1.47 (values ranged from 0.94 to 2.73). It was particularly high for 4-years (≥1.8) indicating dry conditions, where yields were generally below the average. This analysis showed that yield stability across years increased with SOC. Furthermore, we used analysis of covariance to analyse annual yield responses to pH, N limitation and SOC. The resulting slopes of partial regression coefficients representing annual yield responses to changes in SOC were positive for all years. Correlations showed that these slopes increased with the aridity index (R2 = 0.71), indicating that the impact of SOC on crop yield was stronger under dry seasons. For this clay loam soil (Eutric Cambisol), we estimated that the SOC-induced improvement of soil structure increased plant-available water capacity by up to 15 mm per unit percentage increase in SOC. We conclude that SOC accrual is a promising adaptation strategy for increasing yield stability and reducing crop vulnerability during dry periods—an increasingly important consideration as climate change is expected to intensify drought frequency, even in relatively humid regions like Sweden.

ACKNOWLEDGEMENTS

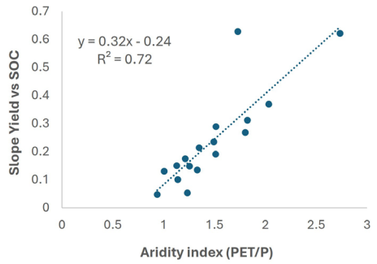
The work was funded by the Swedish Government Research Council for Sustainable Development (FORMAS, grant 2022-00214).

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Maize yield response to SOC content averaged over 20 years for the experimental treatments grouped into five classes depending on N supply and soil pH



Slopes of partial regression coefficients representing annual yield responses to changes in SOC versus aridity index during corresponding growing seasons

GT 10 - 267 - O

SOIL CARBON POOLS IN DIFFERENT SOIL TYPES MANAGED WITH PRESCRIBED FIRES IN THE VALENCIAN COMMUNITY

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Disturbance by fire is often considered to lead to C losses because the combustion of plant biomass and soil organic matter, and post-fire erosion, reduces organic C inputs in the soil reservoir. However, incomplete combustion can induce several transformations that can offset the immediate C losses and may ultimately stabilize the ecosystem's C.

The soil organo–mineral interactions can play an important role in soil organic carbon (SOC) stability and preservation, adsorbing or occluding SOC and hindering the ability of microbes to decompose it [1]. This depends on edaphic characteristics (e.g., soil type, soil aggregation, type and content of clay, etc.), which can be thermally modified depending on the soil fire severity.

Fire management strategies, as prescribed fires, can influence the persistence of SOC and could enhance their stability by reducing the soil fire severity thorough limiting fuel biomass loads and/or by increasing SOC stability by affecting the aggregation, the amount of particulate organic C (POC), the organo-mineral associated fractions (MAOC) and the soil inorganic carbon (SIC).

Here, we analyse how prescribed fires affect the content for different pools of organic and inorganic C fractions (POC, MAOC, SOC and SIC) over time (before, after and between 2-4 years after), to better understand how this management practice influence the response of soil C storage in different Mediterranean soils and vegetation types: i) Quercus robur stand over Rendzic Leptosol (LPk); ii) shrubland over Chromic Luvisol (LVx) and, iii) grassland with spotted Juniperus oxycedrus over Calcaric Regosol (RGc). The study areas are located in Castell de Castells (Alicante, Spain) and Morella la Vella (Castellón, Spain), where the Directorate General of Forest Fire Prevention (DGPIF, Generalitat Valenciana) has carried out prescribed fires between 2020 and 2023.

In all the studied soil types, POC is the dominant fraction at the 3 sampling times, being the POC/MAOC ratio before fires of LVx: 5 > LPk: 4 > RGc: 3. Furthermore, the MAOC fraction increased immediately after prescribed fires, returning to the initial values after several years. For LVx and RGc soils, no differences in SOC were observed along the studied period (averaging 110 and 48 mg g-1, respectively). However, on LPk soil with a rich organic horizon, the use of prescribed fires promoted a SOC increase (from 92 to 168 mg g-1) while minimising the organic layer combustion. This increase is maintained over two years after prescribed fire (146 mg g-1), and it seems to be an effective way to protect standing C stocks from future losses.

ACKNOWLEDGEMENTS

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GT 10 - 274 - O

SPATIAL PATTERNS OF SOIL ORGANIC CARBON IN GERMAN FORESTS: APPLICATION OF RANDOM FORESTS FOR DIGITAL SOIL MAPPING

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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The diversity of forest soils in Germany plays a crucial role in the stability of forest ecosystems. In particular, the small-scale, heterogeneous distribution of soil organic carbon (SOC) provides valuable insights for forest management and evidence-based policy making - especially for the development of soil protection strategies, adaptation to climate change and the promotion of ecological and site-specific forest management. The first and second National Forest Soil Inventories (NFSI I and II) provide point-based, nationwide data on soil properties, including SOC. However, these data are collected using an 8 km × 8 km sampling grid, which does not allow detailed assessments of the fine-scale spatial distribution of SOC in forests. The aim of this study was to regionalize point-based SOC measurements using machine learning techniques and to test an alternative approach to classical geostatistical interpolation methods. At the same time, the study sought to identify the environmental variables that predominantly influence the spatial heterogeneity of SOC. For modelling purposes, raster datasets on climatic conditions, topographic parameters, forest structure indices, atmospheric deposition, parent material and land use were used. These environmental predictors formed the basis for the development of several random forest models, with only informative variables selected through multicollinearity analysis. The models were validated and used to generate SOC maps with a resolution of 10 m x 10 m for topsoil (0-30 cm) and subsoil (30-100 cm). The R2 was 0.45 for topsoil and 0.51 for subsoil. Overall, the application of random forest proved to be a promising method for SOC regionalization and offered several advantages over classical geostatistical approaches - especially in the identification of relevant environmental predictors. Future studies could apply this method to the regionalization of additional, partly correlated soil properties.

KEYWORDS:

soil organic carbon – forest soils – regionalization – machine learning – random forest

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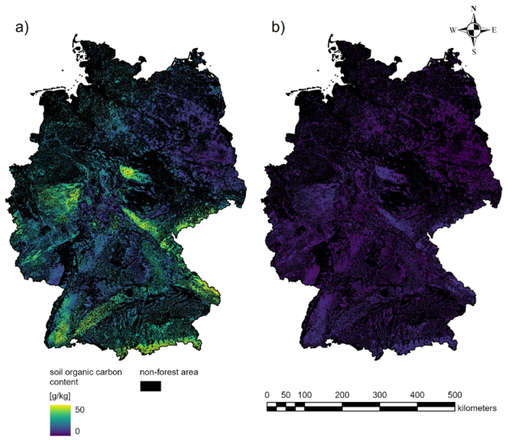


Figure 1: Soil organic carbon content [g/kg] of German forests.
a) Shows the content of the topsoil (0–30 cm), ranging from 7 to 50 g/kg. b) Shows the content of the subsoil (30–100 cm), with values between 0 and 10 g/kg. Black areas represent non-forest regions.

GT 10 - 298 - O

IMPACT OF MANAGEMENT INTENSITY OF AGRICULTURAL SYSTEMS ON SOIL ORGANIC CARBON STOCKS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Agricultural practices frequently lead to the depletion of soil organic carbon (SOC) and release of greenhouse gas emissions, thereby exacerbating global warming and promoting land degradation. Implementing measures to preserve or fix carbon into soils becomes crucial for improving soil health and building sustainable agroecosystems. SOC stocks respond to site-specific conditions, as result of complex interactions between climate, soils, land use, and management practices. However, the coupled effects of these factors on SOC dynamics are not fully understood. This research aimed to evaluate the impact of different farming systems on SOC stocks and identify promising pathways that can boost carbon sequestration in agricultural soils. This study relied on data from the Signpost Programme, which includes information on physical-chemical properties of 148 soil profiles distributed across southern Ireland. Each site was sampled at four depths (0–15, 15–30, 30–45, and 45–60 cm) and characterized according to the land use and cultivation practices implemented over the past five years. Regression Tree technique was employed to predict pathways of potential SOC stocks based on soils' characteristics and management regimes, as well to understand the role that each factor plays within the pathways. Preliminary results suggest that existing SOC stocks are strongly influenced by soil characteristics, while management activities contribute to fluctuations within soil type's ranges. The model highlighted major differences between SOC stocks in profile depths, with average values of 41 and 14 Mg ha-1 for topsoils and subsoils respectively. Soils with the presence of thick organic layers, presented the highest averages (93 and 40 Mg ha-1 in topsoils and subsoils respectively) in comparison with other soils (36 and 12 Mg ha-1 in topsoils and subsoils respectively). Grassland systems presented higher stocks compared to tillage crops, but ranges vary according to soil types. Farming system intensities, grazing stocking rates, nitrogen fertilization, and manure application, stand out as potential causes of SOC stocks fluctuations. The outcomes of this study can help tailoring carbon farming strategies, based on the combination of management practices that boost carbon sequestration accounting for specific soil conditions.

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GT 10 - 319 - O

THE TWO FACES OF THE SOIL CARBON COIN: ORGANIC AND INORGANIC C DYNAMICS AS AFFECTED BY AGRICULTURAL MANAGEMENT IN CALCAREOUS SOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Agricultural management affects the cycle of both soil inorganic carbon (SIC) and soil organic carbon (SOC), but the former has deserved much less attention than the latter when assessing its effect in the global C cycle. Indeed, SIC dynamics is faster than previously assumed, and studies have revealed an acceleration of SIC turnover over just a few decades [1] driven by agricultural management of calcareous soils [2].

Among the practices known to interfere on both SIC and SOC dynamics, there are the use of exogenous organic amendments [3], [4] and the introduction of irrigation in drylands [5], [6].

We have monitored the effect of these management practices by studying the processes affecting SIC and SOC at two scales. First, the effect of the use of sewage sludge in a long-term experiment (25 y) on SOC and SIC storage, where carbon typology and interactions were assessed by physical and isotopic fractionation of topsoil samples. Results indicate a lower-than-expected increase in SOC storage, significant only at the highest doses (>60 Mg/ha), but with a clear change in the nature of organic matter (assessed by Rock-Eval pyrolysis). In addition, while no differences are observed in bulk soil SIC storage, changes in soil pH are observed after 25 y. The change of SIC fractions (carbonate typology and distribution) is likely the cause of this acidification.

Second, a study in a mid-term corn field trial (10 y) under irrigation revealed a clear change in the SOC turnover compared with a rainfed area, particularly relevant in the most labile fractions (particulate OC). In this case, higher carbon inputs were the leading factor explaining the gain in SOC in the irrigated soil.

With respect to SIC, a pot experiment was conducted in a calcareous soil with different doses of an exogenous Ca2+ source (gypsum) and planted with three plant species. At the end of the growth cycle, the amount of bulk soil carbonates was analysed and root samples were extracted for microscopic analysis to identify any calcified roots and associated carbonate features. The results demonstrate that higher gypsum content significantly increased carbonates in the substrate and root calcifications, confirming that gypsum dissolution supplies enough Ca^{2+} for calcite precipitation.

Future analyses, such as 87ð/86Sr ratios and Sr^{2+}/Ca^{2+} proportions of the carbonates (indicators of Ca^{2+} origin) and micromorphological and digital quantification of calcitic soil features using thin sections, will provide a deeper understanding of these processes.

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GT 10 - 323 - O

SOIL ORGANIC CARBON DYNAMICS UNDER INCREASED SALINITY AND TEMPERATURE IN SEMIARID IRRIGATED SOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soil organic carbon (SOC) is a fundamental component of soil health, fertility, and climate regulation. In semiarid regions, irrigated agricultural orchards, key systems for food production and rural livelihoods, are increasingly exposed to climate-induced stressors. Rising temperatures and the use of low-quality irrigation water are accelerating soil salinization, threatening carbon stabilization processes, microbial activity, and overall soil structure. These pressures are particularly concerning in perennial systems such as orchards, where long-term soil sustainability is critical for productivity and carbon sequestration potential. We conducted an incubation experiment to investigate the combined influence of temperature (two levels: 19°C, as current mean annual temperature of the area, and 21°C, as IPCC projections for 2030-2050) and salinity (three levels: S1: 1 mS cm^{-1}, S5: 5 mS cm^{-1}, and S10: 10 mS cm^{-1}) on soil organic matter dynamics, greenhouse gas emissions, nutrient availability, and soil aggregate stability, using soil samples from a semiarid irrigated apple orchard (Malus domestica Borkh var. Gala) in northern Tunisia. The treatments were randomly arranged in an incubator, with five replicates assigned to each one. Soil moisture was maintained gravimetrically at 60% of the water holding capacity. Soil samples were analyzed to determine soil pH, electrical conductivity (EC), SOC, particulate organic carbon (POC), soluble C, mineral-associated organic C (MAOC), nitrogen content, available nutrients, stable aggregates fractions, and the mean weight diameter of soil aggregates. Our findings showed a negative correlation between electrical conductivity (EC) and soil pH ($R = -0.47$, $p < 0.05$). Variations in salinity and pH were linked to alterations in the labile fractions of SOC and in soil structure stability. Increasing salinity reduced NO_3^- at 19°C, likely promoting denitrification through interactions between $K^+$and available N. POC increased at 21°C, suggesting elevated temperature fosters labile C pool formation. Soil aggregate stability, expressed as mean weight diameter, was higher at low salinity at 19°C, and across all salinities at 21°C. Overall, temperature emerged as the primary stressor destabilizing SOC dynamics, while salinity exacerbated these effects. This study offers important understanding of how soil responds to increasing salinity and projected global temperature rises short-term.



GT 10 - 326 - O

FROM PROCESS STUDIES TO FIELD TRIALS: LESSONS LEARNED FROM C FARMING EXPERIMENTATION IN FINLAND

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The 4 permille initiative launched in 2015 increased awareness and research on the importance of soils in climate change mitigation and carbon (C) sequestration. In Finland, the CarbonAction network (www.carbonaction.org) started in 2018 to implement the 4 permille targets, the aim being to study soil C sequestration in the process level to understand the mechanisms behind soil organic C (SOC) stability, but also to test farming practices promoting SOC sequestration in controlled field trials and in actual commercial farms. The experimental period lasted 4-5 years. The aim of this presentation is to summarize the key findings of these studies to draw general conclusions and to give future recommendations.

Here, we hypothesize that 1) higher plant diversity leads to higher productivity and microbial biomass, causing an increase in stable SOC leading gradually to higher C stocks in soils. 2) Increasing carbon use efficiency (CUE) of microbes increase SOC whereas microbial priming counteracts SOC sequestration.

We investigated, up to one meter depth, how 24 years of different management practices (conventional, organic and unmanaged natural meadow) change SOC stocks, MAOC/POC share, fungal community structures and the abundance of various SOC stability markers or indicators. In addition, we studied how increasing cover crop diversity over winter period affects soil microbiology and how this plant diversity affects CUE and priming in topsoil and subsoil. The process-level studies are compared to SOC stock changes observed after 4-5 years in a controlled cover crop plant diversity experiment and in approx. 70 farms that performed a field trial alongside their commercial agronomy.

We observed significantly higher SOC stocks in meadow but also in organic farming compared to conventional practices after 24 years. It seems that organic fertilization and higher root C inputs may explain the differences. In depth-wise profiles and across the different management practices, stability indicators (RockEval stabile C, MAOC, 14C, 13C, aminosugars, GRSP proteins) showed contrasting patterns indicating that indicators used as SOC stability estimates measure different things and may not be comparable. Microbial biomass and carbon use efficiency (as trend) was shown to increase by increasing plant diversity, and in deeper soils, CUE but also priming was higher. This leaves it uncertain how fresh C inputs into deeper soils affect the SOC stocks. In the field level trials, only minor SOC changes were observed but a general pattern of soils losing C was observed, despite C farming practices. However, there were some exceptions, e.g. certain cover crops seem to increase SOC stocks even in a short experimental period.

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GT 10 - 398 - O

STOCKS AND DYNAMICS OF PEDOGENIC CARBONATES IN ARID TROPICAL SOILS, COMPARISON BETWEEN IRRIGATED AGRICULTURE AND AGROFORESTRY

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soils play an important role in the global carbon cycle. SIC (Soil Inorganic Carbon) is assumed to have much longer turnover rates compared with SOC (Soil Organic Carbon) pool. However, this stock may be destabilized by intensive agriculture, which is of major concern in the context of climate change mitigation. This phenomena seems to be particularly important in tropical zones, where SOC stocks are already strongly depleted [1] [2]. In Southern India (Berambadi watershed, SNO M-TROPICS), we studied different types of pedogenic carbonates, quantified associated carbon stocks both in the fine (<2mm) and coarse fractions and 14C-dated populations down to 10m depth thanks to two highly instrumented deep observation wells. One is located in an irrigated agricultural context (IP), the other in an agroforestry context (AF). They were equipped with deep profiles of pCO2 sensors and root scanners, window profiles to trap soil CO2 and Rhizons® pore water collectors.

Most of the carbon stocks related to pedogenic carbonates were located between 1 and 2m depth and consist of coarse calcrete fragments formed 12ka ago. Deeper down, the carbonates consist of coarse nodules (i.e., multi-centimetric kidney-shaped nodules with central septaria and vertical tubular rhizolith-type nodules) of various ages. From 4 to 10m depth, their morphology evolves mainly towards rhizoliths with ages ranging from 6 to 36ka. Deep rhizoliths are composed of 2 types of carbonate: (1) concentric precipitates of sparitic calcite around the root having incorporated soil minerals, and (2) fine carbonate coatings richer in Mg. These Mg-rich carbonates are formed at a distance from the roots (5mm at least), including around present-day roots, suggesting that the 2 carbonate-forming processes are contemporaneous with each other and occur close to or within the seasonally waterlogged horizons. The deepest rhizoliths, 10-11ka old, were formed by deep roots contemporary with or slightly younger than those that formed the calcretes. Millimetre-sized carbonate populations (not yet dated) were also observed in the vicinity of living deep roots in the agroforestry pit, so their formation may still be active.

Stability of pedogenic carbonates was assessed by analyzing δ13C signatures and apparent 14C ages of bulk material, pCO2 and alkalinity of pore solutions at different depths. Where roots are present (IP surface and AF) pCO2 14C is modern. In the deep, rootless zones (IP), δ13C and apparent 14C age (0.34ka) imply a significant carbonate contribution to pCO2, as well as in the alkalinity of IP pore waters, highlighting pedogenic carbonates degradation.

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GT 10 - 409 - O

ADVANCING MEDITERRANEAN CARBON FARMING THROUGH DIGITAL TOOLS AND PREDICTIVE MODELLING

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The Carbon Farming MED project (Interreg-Euro MED) aims to strengthen the resilience of Mediterranean agroecosystems by promoting carbon farming as an innovative green business model. It supports farmers in optimizing soil carbon sequestration and facilitates their access to voluntary carbon markets. The project has delivered methodological frameworks, soil health indicators, and decision-support tools through a multidisciplinary approach integrating soil science, policy, and stakeholder engagement.

An innovative, four-step, multi-actor methodology was developed, comprising: (1) a theoretical framework; (2) field testing of agricultural practices coupled with SOC (Soil Organic Carbon) stock modelling; (3) the development of a digital platform for quantifying carbon removals; and (4) a targeted dissemination and communication strategy.

Eight pilot farms—five in Italy and three in Catalonia—were established and monitored to support SOC model calibration. A catalogue of carbon farming initiatives was compiled to explore synergies, and a comprehensive communication strategy was implemented to promote the project's outcomes.

The digital platform integrates a GHG accounting module based on IPCC equations, a SOC prediction model tailored to Mediterranean conditions (Farina et al., 2013), and a baseline estimation approach using chrono sequences (Apostolakis et al., 2017). Its development was guided by a transdisciplinary team including scientists, technical developers, and agricultural stakeholders, ensuring both scientific integrity and user relevance. These components enable robust quantification of potential carbon removals resulting from improved agricultural practices.

Key achievements include the creation of a tailored carbon farming framework for the Mediterranean region, incorporating a set of indicators and predictive models, adapted MRV requirements and standards, funding strategies, recommended agricultural practices, co-benefit assessments, and a techno-economic model. With these achievements, the Carbon Farming MED project advances the adoption of sustainable farming practices through digital tools and predictive modelling, helping mitigate climate change while offering economic benefits to farmers in the Mediterranean region.

ACKNOWLEDGEMENTS

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GT 10 - 423 - O

FE-MEDIATED STABILISATION OF RHIZODEPOSITED CARBON AND ITS INFLUENCE ON SOIL STRUCTURE IN POORLY STRUCTURED SOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Alkaline soils cover over 1.38 billion hectares globally, dominating dryland agricultural regions. These soils typically have low organic carbon (OC) content, which limits their agricultural productivity. In Australia, approximately 65% of soils are poorly structured, an issue closely linked to OC depletion. Iron minerals can stabilise OC through organo-mineral associations with short-range-order iron oxides such as ferrihydrite (Fh). However, most research has focused on Fe-OC interactions in Fe-rich or acidic tropical soils. As a result, little is known about the role of reactive Fe minerals in OC stabilisation in alkaline soils. This research gap is partly due to the traditional assumptions that reactive minerals play a minor role in dryland systems. However, recent evidence shows that ~79.8% of mineral-associated organic carbon (MAOC) in arid soils is stabilised by Fe oxyhydroxides (Tang et al. 2025).

A 56-day incubation experiment was conducted using an alkaline subsoil to investigate the effect of Fh and a redox mediator (AQDS) on OC stabilisation. Treatments included: (1) untreated control, (2) Fh at 3.6 g kg-1, (3) AQDS at 100 µM (0.41 g kg-1), and (4) Fh + AQDS. We hypothesised that Fh would form Fe-bound OC complexes that protect OC from microbial degradation and AQDS would further reduce Fe3+ to Fe2+, therefore enhancing Fe-OC formation. Our results showed that combined Fh and AQDS significantly reduced basal CO2 emissions by up to 32% compared to the control and increased Fe-bound OC. Synchrotron-based carbon K-edge Near Edge X-ray Absorption Fine Structure spectroscopy revealed that carboxyl and phenolic functional groups contributed to rapid adsorption of OC onto Fe surfaces, with phenolic-C increasing with Fh addition.

Next, we have initiated a 13CO2 pulse labelling experiment on wheat to trace rhizodeposit-13C and examine its fate in the presence of Fh. Over five weeks, we will assess 13C allocation into CO2, particulate organic carbon (POC), and MAOC fractions, and measure changes in water-stable aggregate stability. We hypothesise that (1) soils amended with Fh will retain a higher proportion of rhizodeposited carbon in the MAOC pool compared to the POC pool, and (2) Fh will suppress the microbial mineralisation of native soil OC in response to rhizodeposition. This work builds on our previous findings and aims to bridge geochemical and biological processes, offering insight into how Fe minerals influence rhizosphere-driven carbon stabilisation and structural improvement in poorly structured soils.

ACKNOWLEDGEMENTS

This research is supported by the University of Adelaide and the Grains Research and Development Corporation (GRDC; Reference No: UOA2501-007RSX).

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GT 10 - 424 - O

UNPACKING THE ROLE OF LIVESTOCK DIVERSITY IN SOIL PROCESSES AND CARBON DYNAMICS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Livestock diversity influences ecosystem functioning, yet its effects on soil functions remain understudied. We evaluated how different grazing regimes affect ecosystem multifunctionality, focusing on nutrient cycling, soil carbon storage, enzymatic activities, and soil respiration, before and after compost addition. Soils were collected from an organically managed Mediterranean farm in southern Spain under three grazing treatments—ovine, equine, and exclusion—for a controlled container experiment to assess responses to compost addition.

Before compost application, the livestock exclusion area showed higher total carbon, nitrogen, and soil organic matter, likely due to the absence of disturbance. Compost application reduced water-soluble carbon by 39%, especially in exclusion plots, and interacted with livestock type to modulate pH, electrical conductivity (EC), and available potassium (K), with the most notable increases in EC and available K observed in soils under equine livestock. Compost application strongly affected soil enzymatic activities. Urease activity decreased by 64%, while glucosaminidase increased by 63%, regardless of grazing regime. β-glucosidase was highest in exclusion soils and markedly reduced under grazing. Phosphatase activity rose across all treatments, with ovine soils showing the greatest increase. Dehydrogenase and aminopeptidase responses to compost addition were livestock-dependent, increasing in equine and exclusion soils but declining in ovine plots. Compost addition reduced carbon mineralization and priming effects across all treatments, with equine plots exhibiting consistently negative priming effects over time. Cumulative CO_2 respiration and priming were highest in ovine soils without compost, intermediate in exclusion areas, and lowest in equine-managed soils, where compost seemed to suppress microbial activation triggered by labelled litter amendment. These findings suggest that livestock type and management history play a crucial role in determining the soil's response to organic amendments. While exclusion areas preserved higher baseline fertility, equine-managed soils showed greater responsiveness to compost inputs, especially in terms of nutrient availability and enzymatic activity recovery. In contrast, ovine systems, despite higher baseline respiration and nutrient cycling, were more responsive to compost in terms of soil respiration and priming effect modulation. This highlights the importance of tailoring amendment strategies to existing soil conditions and grazing practices to optimize soil health and carbon sequestration potential.

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GT 10 - 432 - O

SHIFTS IN MICROBIAL CUE AS A FUNCTION OF AVAILABLE ORGANIC C RESOURCES AND ELECTRON ACCEPTORS UNDER CHANGING SOIL REDOX CONDITIONS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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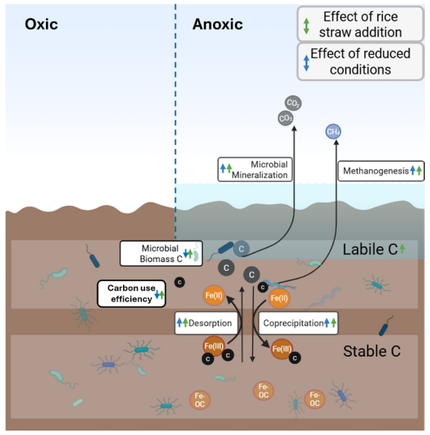
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Soil microbial carbon use efficiency (CUE) affects the fate of belowground C, making it either a C source or sink. This CUE is largely affected by environmental factors but also organic C and electron acceptors quality and availability. This is particularly the case in soils that experience shifts in redox conditions. Indeed, when soils are water saturated, such as in rice paddies, microorganisms will shift their metabolism from using O2 to using alternative electron acceptors including NO3- and Fe(III). These changes in metabolic activities may also be accompanied by a shift in microbial communities which are more adapted to such an environment and use available resources more efficiently affecting the overall CUE. The aim of this work is to explore the effects of short-term (i.e. 17 days) changes in soil redox conditions (i.e. from aerobic to anaerobic) on microbial physiology in rice paddy soils, particularly on growth, respiration and CUE, as a function of the availability of labile organic C substrates (electron donors) and electron acceptors known to be influenced by soil properties and management practices, as well as their dependence on changes in microbial structure and composition. For this we have set up a microcosm experiment where a typical rice paddy soil was incubated under aerobic or anaerobic conditions, with or without the addition of rice straw (electron donor) and NO3- in a complete factorial design. Soils were sampled on days 4 and 17, and microbial respiration and growth were evaluated by measuring the rate of CO2 production and 2H incorporation into PLFA after incubation with D2O. Our results show that, in the absence of O2, NO3- was rapidly consumed over the first 4 d while Fe(III) reduction was most evident after 17 d, especially in the presence of rice straw. Moreover, the reductive dissolution of Fe oxyhydroxides led to an increase in DOC in the soil solution, that was further enhanced in the presence of rice straw. Microbial respiration was higher and more sustained in time under anoxic conditions. On the other hand, microbial growth rates were enhanced by the addition of labile C for both redox conditions and remained stable overtime under anoxic conditions while under oxic conditions they decreased where rice straw was added. However, the CUE is much lower under anoxic conditions and does not show such responses to the C supplied. This is mainly due to the higher respiration rates, which may occur to maintain a certain growth rate as well as to support the shift in soil microbial community under reducing conditions. In particular, the increase in biomass C production of gram-positive and gram-negative bacteria, which is particularly pronounced after 17days.



Conceptual model of the microbial CUE under changing redox conditions and C substrates



GT 10 - 446 - O

EFFECTS OF COVER CROPS AND NO-TILLAGE ON SOIL ORGANIC MATTER DYNAMICS IN A MID-TERM FIELD EXPERIMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Addressing the challenge of enhancing soil health and carbon sequestration through sustainable agricultural practices requires a clear understanding of how management strategies influence soil organic matter (SOM) dynamic over time and along the soil depth. This work aimed to assess the effects of different cropping systems on SOM distribution and quality in a 10-year wheat-maize rotation trial, investigating soils down to 60 cm depth.

The three systems studied were: integrated management without cover crops and conventional tillage (CONV); organic management with grass-legume cover crops, temporary wheat-faba bean intercropping and conventional tillage (ORG); integrated management with grass-legume cover crops and no-tillage (NOT). In each plot, a soil profile was dug and sampled by horizons. Soil samples were fractionated to isolate the labile, stable and resistant SOM pools, according to Zimmermann et al. [1]. Within the stable pool, sand-size (SSA) and silt- and clay-size (SCA) aggregates were isolated. Organic C (OC) content and stocks were measured for bulk soil and pools, and microbial biomass and activity determined per horizon. Given differences in organic inputs, aggregate distribution and microbial activity, we further analysed the chemical composition of stable SOM. Mineral-associated organic matter (MAOM) was isolated from the soil samples following Just et al. [2] and analysed by solid-state 13C CPMAS-NMR spectroscopy.

Total OC stocks (0-60 cm) were similar across the cropping systems, while differences were found in their vertical distribution. In NOT, the absence of tillage favoured the accumulation of OC in upper horizon, whereas in CONV and ORG systems the OC was more homogeneously distributed throughout the soil. Stable SOM was the dominant pool in all the systems. ORG and NOT soils showed a greater proportion of OC associated with SSA than CONV, in which OC was mainly associated with SCA. The use of cover crops and no-tillage seems to promote the development of macrostructure. Despite similar C microbial biomass, ORG and NOT recorded larger microbial activity than CONV, suggesting higher mineralisation rates. Nevertheless, the chemical characteristics of MAOM did not differ significantly between systems, except in the upper horizon of NOT, where higher proportions of O-alkyl C were detected due to the presence of more labile compounds (e.g., polysaccharides, cellulose).

We assumed that 10 years would not be enough to affect the stable SOM composition when new agricultural practices were implemented. However, biological indicators and changes in soil structure already highlight early system effects. Future research efforts should extend the duration of studies and consider repeated measurements over time.

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GT 10 - 453 - O

ADVANCING MODELS FOR ESTIMATING SOIL ORGANIC CARBON DEFICITS USING LEGACY-DATA-DRIVEN DYNAMIC BASELINE AND ATTAINABLE PROJECTIONS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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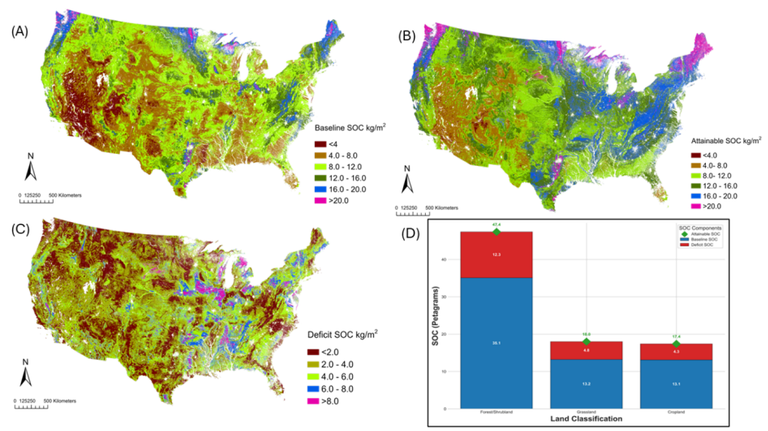
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Soil organic carbon (SOC) stocks vary through time and across land use, climate, and soil type, making large-scale modeling of current SOC (SOCcs) challenging. The attainable steady-state stock (SOCat), the practically achievable SOC level under optimal soil, climate, and management conditions, is also dynamic because several soil loss pathways impact biophysical factors that control maximum storage capacity and can shift SOCat. Robust methods are therefore needed to model and extrapolate both SOCcs and SOCat so that current deficits (SOCdef = SOCat – SOCcs) can be quantified as unrealized sequestration capacity. Most existing theoretical and data-driven approaches are limited by lack of empirical evidence and temporally rich datasets, making them less reliable for dynamic estimation of SOC reference states from legacy data alone.

To overcome these limitations, we combined legacy SOC observations, time adjustment, and data-driven modeling to generate spatially explicit 2024 SOCcs projections at 250 m resolution for the contiguous United States. We then estimated SOCat by identifying the maximum SOC stock within a spatially constrained similarity matrix of projected SOCcs and, using both reference layers, calculated location-specific SOCdef. The resulting maps reveal pronounced heterogeneity, with mean deficits average 3.46 kg m^{-2} in croplands versus 3.1 kg m^{-2} in grasslands and forests. Larger deficits clustered on historically cultivated Mollisols and Alfisols in the Midwest, although they were lower than anticipated, indicating that decades of land use practices have depleted both SOCcs and SOCat. Degraded grasslands show similarly reduced storage capacity, underscoring the need to recalibrate sequestration targets to today's lower steady states. By providing empirically based, regionally calibrated SOCcs-SOCat-SOCdef benchmarks, our framework offers actionable reference points to align management incentives, climate-smart policy, and site-specific restoration efforts.

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Model projections showing SOCDB in 2024 (A) and SOCAT (B), and SOCDEF (C) at a 250 m² resolution in kg m?².
The bar chart (D) represents the area-based total estimates for SOCDB in 2024, SOCAT, and SOCDEF across various land classifications



GT 10 - 464 - O

THE ROLE OF EARTHWORMS IN ORGANIC MATTER CYCLING IN TEMPERATE FORESTS – A MESOCOSM EXPERIMENT WITH LABELLED BEECH LITTER

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 04. SOIL BIOLOGY

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Earthworms may act as double-edged swords for soil organic matter (SOM). While they can enhance organic matter (OM) mineralization via increased microbial activity, they can also elevate OM stabilization in aggregates as particulate or mineral-associated OM. In this study, we are testing this potentially opposing impact in beech-dominated (Fagus sylvatica L.) mixed forests on limestone, a forest ecosystem with particularly high earthworm activity. A specific focus lies on OM transformation along the continuum from the forest floor (O horizons) to mineral soil (A horizons). The forest floor can represent a substantial OM-pool but can be vulnerable to alterations due to climate change and disturbances. In a lab mesocosm experiment, we are assessing the impact of two local earthworm species with different life strategies on labelled litter and SOM transformation. In soil columns consisting of O and A horizons from two contrasting beech forest sites from 600 and 1250 m elevation in the Swiss Jura Mountain range, we established four earthworm treatments for each site all including the respective mineral soil and forest floor: (1) no worms, (2) two Octolasion cyaneum S. an endogeic species, (3) one Lumbricus terrestris L., an anecic species, and (4) mixture of the two species (mix). In this setup, the Ol horizon was replaced with beech litter highly enriched with 13C, 15N, and 2H. Soil respiration (13CO2) and leaching (13C, 15N, and 2H in dissolved OM) are repeatedly measured from the entire soils as well as separately from A and O horizons. After 4 and 12 months each, a set of mesocosms is harvested to investigate isotope enrichment in earthworm biomass, casts, and physical soil fractions. We find first indications for stabilization of new litter input as, under similar total CO2 fluxes, the litter-derived fraction of the respiration is higher for treatments without worms. At the high elevation site, 22±1% of initial litter-C applied to the Ol horizon was lost from the mix treatment, whereas the no worm treatment lost 28.4±1%. The difference is less clear at the low elevation site with losses of 29±0.8% versus 30.8±0.7%, respectively. As we observed a nearly complete litter mass loss after 12 months in those treatments while litter remained in treatments without worms, we expect L. terrestris to have transferred a major part of the initial litter-C to the mineral soil with minimal losses as DOC. Results from the first 4 months indeed show up to 12% litter-C in the top 2 cm mineral soil in L. terrestris and mix treatments. Further measurements will disentangle the effects of earthworm species on the downward movement via bioturbation and leaching, and the incorporation into soil fractions. X-ray CT and LA-IRMS measurements will inform us about the spatial distribution of OM within the mesocosm system.

GT 10 - 480 - O

SOIL CARBON DYNAMICS ACROSS SEASONS: INSIGHTS FROM CONTRASTING LAND MANAGEMENT PRACTICES IN SPAIN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Soil is the second-largest active carbon reservoir, storing 1,500–2,400 Gt globally, making it critical for climate change mitigation (Lal, 2004; European Union, 2011). Soil carbon stocks are shaped by physicochemical properties, climate, and land use, therefore effective management is key to enhancing carbon sequestration (Paustian et al., 2016; Beillouin et al., 2022). This study examines the impact of seven land management practices on soil carbon and health.

Three samples from each management were taken in semi-arid central Spain under conventional tillage, no-tillage, direct seeding, livestock integration, and unmanaged systems. Each site was characterized for organic matter content (OM%), total organic carbon (TOC), microbial diversity and biomass, and fungal-to-bacterial (F:B) ratios. A composite Carbon Stability Score (CSS) was developed, combining carbon persistence (80%), microbial ratios (15%), and C:N ratios (5%). Greenhouse gas fluxes (CO_2, CH_4) were also measured to compare emissions across practices.

Preliminary results from the March 2025 sampling highlight strong effects of land management on carbon levels and stability. No-tillage and tree-integrated systems had the highest OM%, TOC, and CSS. Tillage substantially reduced microbial biomass and carbon retention, aligning with Beillouin et al. (2022) and Lehmann & Kleber (2015). Soils with more diverse microbial communities and balanced F:B ratios showed greater carbon stabilization. These results reinforce links between microbial ecology and long-term carbon storage (Paustian et al., 2016).

GHG data reveal that emissions are not always inversely related to carbon stocks. Emission patterns appear more influenced by microbial metabolism and moisture regimes than carbon content alone. Conventional tillage emitted nearly three times more CO_2 than all other systems. In contrast, light tillage and animal integration produced lower emissions than an unmanaged plot left undisturbed for 30 years.

To assess seasonal effects, a second sampling in June 2025 will compare early spring and summer soil conditions. This will enhance our understanding of temporal dynamics in carbon cycling and support targeted, climate-smart soil management strategies suited to Mediterranean agroecosystems.

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GT 10 - 516 - O

HOW TREATED WASTEWATER AND BIOSOLIDS FROM THE MUNICIPAL WASTEWATER TREATMENT PLANT AFFECT CARBON DIOXIDE EFFLUXES FROM SOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The aim of this study was to evaluate the gradual effect of repeated applications of sewage sludge or composted sewage sludge, and continuous irrigation with reclaimed wastewater on the CO2 effluxes from soil over a 4-year period. The basic soil properties were also measured. The net CO2 effluxes were measured at the surface of nine beds with two different soils (Cambisol and Arenosol), which were installed next to the outflow channel from the wastewater treatment plant (WWTP). This experiment was primarily established to investigate the transfer of micropollutants from biosolids and treated wastewater to soils and plants [1]. Both biosolids were added into the Cambisol beds every spring before plants' planting or sowing. One bed was enriched with digested sewage sludge taken directly from WWTP and two beds with composted sewage sludge. The other two Cambisol and one Arenosol beds were irrigated with re-claimed wastewater pumped from the canal. The remaining two Cambisol and one Arenosol beds were irrigated with tap water. In 2021, all three beds with biosolids were irrigated with tap water. In 2022, 2023 and 2024, sludge-bed and both compost-beds were irrigated with tap water and wastewater, respectively. Both biosolids positively affected the CO2 emission [2] [3]. While the positive effect of compost increased over time, the effect of sludge was similar every year. Almost no influence of wastewater on the CO2 emission was observed in 2021. However, the higher CO2 efflux values were mostly recorded for the beds irrigated with wastewater than for the beds irrigated with tap water in 2022, 2023 and 2024. Our study showed that wastewater and sewage sludge can increase the CO2 emission from soils, but their effect is not cumulative over time as the compost effect, because the organic matter is likely easily decomposed, and nutrients are either quickly consumed by organisms or washed out of the soil. Composted sludge can significantly increase CO2 emissions from soil. However, much lower doses than in our case can be applied because the organic matter from this source is more stable in the soil environment.

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GT 10 - 549 - O

PARAMETRIZATION OF SOIL ORGANIC CARBON MODELS CONSTRAINED BY 12C, 13C AND 14C SIGNATURES USING DATA FROM A LONG-TERM FIELD EXPERIMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil Organic Carbon (SOC) represents the largest terrestrial carbon (C) pool and makes soils one of the main components in the global C cycle. Various interacting processes influence the C retention and transfer between different SOC pools in space and time, which makes it difficult to understand the mechanisms and to predict the evolution of SOC stocks. It has been shown that a simple dynamic two-pool SOC model (ICBM) could describe the evolution of SOC stocks over 63 years for all the treatments in the Swedish Ultuna frame trial [1]. To improve our understanding of the model parameters regulating SOC dynamics and transfer between pools, we analyzed a time series of archived soil samples for C isotopes (12C, 13C and 14C) in four selected treatments. The 14C signature allowed us to estimate the incorporation and transfer between pools of bomb radiocarbon entering the soil since the 1960s. Since all aboveground plant biomass is removed in this trial, the 13C signature allowed us to estimate the retention of belowground C inputs from maize entering the soil, a C4 crop that replaced the previous C3 crops since the year 2000. The selected treatments were bare fallow (BF), no mineral nitrogen (N) and no straw amendment (-N -Straw), mineral N fertilization alone (+N -Straw), and both N fertilization and straw (+N +Straw). Total SOC stocks increased over time in +N +Straw and decreased in the other treatments, most in BF and least in +N -Straw. We constrained parameters using a Bayesian framework and tested three model structures implemented within the SOILR package [2]: two dynamic pools with or without an inert pool or three dynamic pools. The fast decline in Δ14C after the bomb peak was highest in +N +Straw, indicating a shorter transit time than expected from total SOC dynamics. According to model structures, our preliminary results suggest that this treatment speeded up decomposition of the old or intermediate dynamic pool, which could be interpreted as positive priming. The simpler model structure with two dynamic pools could well describe total SOC dynamics. However, it appears that at least three pools are needed to properly describe Δ14C dynamics. Belowground C inputs from maize were closely correlated with 13C signatures in SOC affirming the importance of root-derived C inputs for SOC formation.

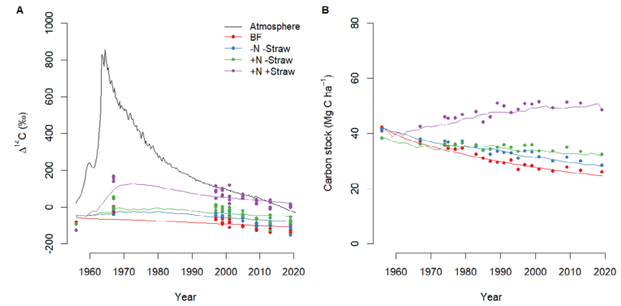
ACKNOWLEDGEMENTS

The work was funded by the Swedish Government Research Council for Sustainable Development (FORMAS, grant 2022-00214).

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Simulation of 14C (A) and total soil organic carbon stocks (B) for four treatments in the Ultuna frame trial using a model structure with three dynamic pools. Lines and dotes represent simulated and observed values, respectively. Legend meaning: BF, bare fallow; -N -Straw, no mineral nitrogen fertilization and no straw amendment; +N -Straw, nitrogen fertilization alone; +N +Straw, nitrogen fertilization and straw amendment.



GT 10 - 555 - O

SHORT-TERM EFFECT OF DIFFERENT AGRONOMIC MANAGEMENTS ON SOIL PARTICULATE ORGANIC MATTER (POM) AND MINERAL-ASSOCIATED ORGANIC MATTER (MAOM) CONTENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil organic matter (SOM) plays an important role in several UN sustainability goals and is considered a key strategy in the fight against climate change. It stores carbon (C) derived from the photosynthetic conversion of atmospheric CO_2 into plant biomass. The partition of SOM into two fractions, particulate organic matter (POM) and mineral-associated organic matter (MAOM), is recognized as a method to understand and predict SOM dynamics across different ecosystems, along soil depths and over time. These two fractions are considered distinct in their formation, function, and dynamics in the soil. POM consists of complex molecules accessible to decomposers, while MAOM is composed of simpler, smaller molecules, that are largely inaccessible to decomposers because it is bound to soil minerals.

This research was conducted in North-east Italy. We investigated the short-term effect of six different agronomic strategies—based on the combination of two organic fertilizers (compost – C and digestate – D) and three winter cover crop management practices (triticale every year – T, different cover crop species succession – S, weedy fallow – W)—on the total and POM and MAOM fractions of soil organic carbon (SOC) and nitrogen in the 0-40 cm soil profile after 5 years in a maize-soybean rotation. The soil from a six-year-old forested area (FA) present in the same experimental site served as the control treatment.

The SOC stock in the 0-40 cm soil profile was significantly higher (+ 43.4%) in the treatment where organic fertilization and a succession of cover crops were adopted than FA (46.0 Mg ha-1). The SOC stock in the soil of other treatments (on average 52.1 Mg ha-1) was not significantly different to the values found in C-S and FA. C-POM stock did not significantly differ among treatments, with an average value of 12.8 Mg ha-1. C-MAOM stock was instead significantly higher in C-S soil (51.9 Mg ha-1) than C-W and FA soil (on average 34.8 Mg ha-1). The other treatments showed a C-MAOM stock of 42.7 Mg ha-1 which was not significantly different than the above reported treatments.

Although further observations need to be conducted in the coming quinquennia to confirm the short-term trends observed, the results indicate that forested area with following no-tillage management does not fix more SOC than a tilled agricultural soil with high organic matter inputs. Moreover, specific agronomic management practices of cultivated soil can even significantly increase the stable fraction of SOC compared to FA.

ACKNOWLEDGEMENTS

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (Missione 4, Componente 2, CUP C93C22002790001). Spoke 4, Work Package 4.2, Task 4.2.1 "Farm network setup (Living Labs): a network of farms representative of the different agricultural systems to apply innovative technologies for the sustainable management of crops, animals and forests".

GT 10 - 560 - O

SPATIO-TEMPORAL CONTROLS OF SOIL RESPIRATION IN A MIXED FOREST IN THE SOUTHWESTERN FOOTHILLS OF THE BLACK FOREST (GERMANY)

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Introduction: Next to photosynthesis, soil respiration (Rsoil) reflects the second largest CO2 flux in ecosystems and can account for 60-90% of the total ecosystem respiration (REco), yet spatial and temporal controls across scales are difficult to quantify. Extreme weather conditions such as drought or heavy rain are expected to occur more frequently under climate change and could mediate temporal and spatial hotspots for the CO2 production in forest soils. Within the framework of the SFB1537 ECOSENSE our aim is to quantify and explain rarely investigated spatio-temporal patterns of small scale heterogeneity of soil CO2 fluxes in a mixed forest stand.

Material and Methods: The ECOSENSE forest site is located in the foothills of the southwestern Black Forest (Germany) and consists dominantly of European beech (Fagus sylvatica) and Douglas fir (Pseudotsuga menziesii) growing on Dystric Stagnic Cambisols (loamic) and Dystric Skeletic Cambisols (siltic, humic). For our soil respiration measurements, we used a new mobile open-bottom chamber with a solid state CO2 sensor controlled by a Raspberry microcomputer. Through the given mobility of our system it can be applied at many places providing the possibility to cover measuring our area within one day. Spatio-temporal patterns were assessed by weekly to fortnightly repeated measurements of 35 plots distributed through the research area over two years (2023-2024). The patterns were then analysed using a multiple-mixed regression model that considers weather, phenology, tree distribution and soil physical chemical and biological properties.

Results: RSoil correlated with local associated soil temperature, which represents the main controlling parameter over the whole measurement period. During a phase of low rainfall, RSoil collapsed over 4 weeks. After first rainfall events, RSoil reached a maximum within the whole measured period. Plots dominated by Fagus sylvatica show higher RSoil than plots dominated by Pseudotsuga menziesii only during the summertime. In terms of soil biological parameters, we found a positive correlation between RSoil, root density and biomass also only during the summertime. Weather conditions showed both short-time-lagged effects (e.g. vapor pressure, air temperature) and long-time-lagged effects (e.g. global radiation, precipitation) on the current RSoil. The weather parameters and seasonality in the model alone explain up to 80% of the variation in RSoil.

Conclusion: Our present dataset achieves a high spatial resolution not often found in other studies. Within the framework of our SFB we are able to calculate the contribution of RSoil to REco, which gives us fundamental knowledge of the interaction in soil-plant environments. Our analysis showed influences of weather phenomena, which are of crucial importance in the scope of climate change and therefore provide us a better understanding of the development of hotspots in forest soils in a spatial and a temporal context.



GT 10 - 571 - O

FROM DEGRADATION TO STABILIZATION: ASSESSING MINERAL SOIL COVERAGE IN AGRICULTURAL PEATLAND MANAGEMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Peatland management in north-western Europe represents a major challenge. Pristine peatlands have the capacity to store vast amounts of carbon, making their conservation essential for climate regulation. However, in Switzerland, as in many other parts of Europe, peatlands were historically drained to promote economic development and create fertile agricultural land. While beneficial for farming, this process exposed peat to accelerated degradation, leading to substantial CO_2 emissions. Today, there is a pressing need to explore methods that can reduce these emissions while preserving enough fertile soil to sustain a growing population.

In Switzerland's Three Lakes region, a method known as mineral coverage was introduced more than 50 years ago. Initially, it was implemented to facilitate the use of heavy machinery on fields prone to flooding caused by peat degradation, which creates depressions and leads to water stagnation. Although this approach dates back several decades, it is now being re-evaluated not only for its practical advantages but also for its broader impact on soil properties.

Mineral coverage involves applying a layer of mineral soil over peat to physically separate it from the surface, slowing degradation while allowing continued agricultural use. Over time, several variations of this method have emerged.

We analysed ten backfilled soil profiles across the region, assessing carbon composition using $\delta^{13}C$ and DRIFT spectroscopy, and mineral composition using XRD and XRF. These data were combined with micromorphological observations to better understand how mineral additions influence organic matter stabilization and soil function.

Preliminary results show that the composition of the mineral layer varies between sites, ranging from almost pure quartz to carbonate-rich materials. These differences affect soil texture, elemental composition, and the development of soil aggregates. Micromorphological analysis revealed that aggregation in pure quartz sand, even after a long time, is limited and requires significantly more effort to maintain long-term fertility.

$\delta^{13}C$ values suggest better carbon preservation beneath mineral layers, potentially due to higher water tables. This interpretation is supported by micromorphology and DRIFT measurements, which indicate the presence of less degraded organic compounds. Finally, organo-mineral associations appear to be better developed when both organic and mineral components are present, and compaction is avoided. In such cases, aggregates are more porous and less compacted, which may enhance water infiltration.

Overall, while adding a mineral layer appears effective for protecting peat, it may initially delay soil fertility, as bioturbation and aggregation processes require time to develop.

GT 10 - 577 - O

EXPLORING THE RELATIONSHIP BETWEEN BIOCHAR FUNCTIONAL GROUPS AND SOIL CARBON MINERALIZATION DYNAMICS AND PRIMING EFFECT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 04. SOIL BIOLOGY

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Conventional sustainable practices can enhance carbon (C) inputs and protect the soil surface, yet these may also stimulate soil organic C (SOC) mineralization. This trade-off is less pronounced when biochar, a C-rich carbonized material, is used as a soil amendment to promote long-term C sequestration. However, its effects on mineralization may vary with edaphoclimatic conditions and the mechanisms by which it may influence soil C dynamics, in comparison to fresh biomass, remain unclear. Thus, this study compared the effects of two organic inputs, sugarcane straw and its biochar, on CO_2 emissions from a tropical soil, aiming to identify the chemical properties most strongly associated with CO_2 released from different soil C pools. A 56-day incubation experiment was conducted in a completely randomized design with three treatments (n = 4): soil alone or combined with biochar or straw. Both amendments were added at a rate that represented a C input of 1g. Gas samples were collected on days 7, 14, 21, and 28 for δ13C analysis, while total CO_2 emissions were measured until day 56 using soda lime traps[1]. Chemical properties and C bonds at the surface of the organic materials were characterized by X-ray photoelectron spectroscopy. Our results showed that, in the short term, the application of both organic amendments increased total soil CO2 emissions; however, the increase was significantly lower for biochar (19%) than for sugarcane straw (126%), relative to the control. From the total CO_2 emissions, most of the C mineralized in straw-amended soils originated from the decomposition of the fresh organic material. In contrast, in biochar-amended soils, CO2 emissions were more evenly attributed to the mineralization of both the biochar and native SOC. A higher positive priming effect was observed in biochar-amended soils compared to those receiving straw by day 7, but it declined to near zero by day 28, indicating a short-lived response. The two organic materials exhibited slight disparities in C-functional groups, displaying a predominance of aromatic and aliphatic structures (C–C/C=C). The labile fraction of the materials was strongly positively correlated with total CO_2 emissions and the soil priming effect, whereas the presence of recalcitrant C–C/C=C functional groups was more closely associated with the mineralization of native SOC. This relationship indicates that the presence of more stable C-structures in biochar that are more resistant to microbial decomposition correlates positively with the mineralization of native SOC. The present findings highlight biochar's potential to reduce C losses and promote environmentally sustainable agricultural practices. However, its short-term influence on SOC mineralization and the chemical characteristics driving these effects should be considered in future modeling and field-scale applications in tropical environments.

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GT 10 - 619 - O

ROLE OF PLANT LITTER QUALITY ON CARBON SEQUESTRATION POTENTIAL IN RAINFED WOODY CROPS SYSTEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Regenerative and sustainable agriculture practices are widely promoted and adopted by farmers across Europe. These approaches aim to restore soil health and biodiversity, while also improving carbon sequestration, at the same time maintaining high crop yields and preventing soil degradation and water pollution. In the last years, the implementation of cover crops in rainfed woody agroecosystems as almond orchards have spread, as a sustainable agriculture practice in semi-arid areas.

The main objective of this work was to evaluate the effectiveness of cover crops for organic carbon (OC) sequestration and stabilization mechanisms and aggregate formation in semiarid rainfed almond orchards to promote changes in existing conventional agronomic practices from a climate change mitigation perspective. Furthermore, the role of the cover crops litter quality on the carbon sequestration potential is also evaluated.

The work was carried out in three experimental farms of rainfed almonds (Cagitán, Burete and Llano) located in the South East of Spain. Traditional tillage, where the soil remains bare for most of the year, is compared with a spontaneous cover crops and reduced tillage. Our results showed an improvement in soil structure through the formation of new macro and/or microaggregates, depending on the farm, with the implementation of cover crops. In addition, the concentration of OC associated with microaggregates occluded within macroaggregates was higher (13.6 ± 1.4 and 17.0 ± 3.2 mg g-1 aggregate) with cover crops than with traditional tillage (8.6 ± 2.5 and 14.5 ± 1.8 mg g-1 aggregate), in two of the three farms, indicating an increase in the physico-chemical protection of this carbon.

The quality of the vegetation indicated that, the N-O-alkyl-C (labile compounds, mainly polysaccharides and also proteins), were higher under spontaneous cover crops respect to the traditional tillage independently on the farm. Whereas the opposite trend was displayed in the Alkyl-C (decomposed compounds). This led to an A/OA ratio lower, under cover crops than under traditional tillage management (decreasing by about 42%, 25% and 27%, depending on the farm). The farm where the magnitude of the response of the cover crops was more evident was the one showing the most labile plant material (higher percentage of N-O-alkyl-C and lower A/OA ratio compared to traditional management) and the finest texture (silt-loam) of the three farms. Both factors favouring the stabilization of soil organic carbon.

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GT 10 - 633 - O

WHAT IS THE CURRENT CARBON STORAGE AND FUTURE CARBON SEQUESTRATION POTENTIAL OF FOREST SOILS IN THE UK?

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The UK Committee on Climate Change identified several land-use options to contribute to limiting further global warming, Climate neutrality and Net Zero, Biodiversity gain and wider ecosystems services benefits with the restoration, agroforestry, natural colonisation and new planting of woodland identified as robust, low-cost high-quality options. As a result, the UK governmental and devolved administrations have sought ambitious (grant-aided) targets to substantially increase forest cover, e.g. from current 13% to 17% or more by 2050 (Committee on Climate Change, 2020). Forest ecosystems are vital carbon sink, sequestering atmospheric CO2, by fixing C into woody biomass, litter and necromass (Morison et al., 2012), with more than 70% of this carbon stored belowground in forest soils across the UK (Vanguelova et al., 2013).

This presentation will provide an overview of the current carbon storage in the UK forest soils and give examples for potential soil carbon change and sequestration under the variety of woodland expansion options.

The quantification of forest soil carbon stocks, pools and change from past and present forest soil carbon surveys, resurveys and studies carried out within the UK will be first presented. Forest soil stocks and pools under main tree species and forest soil types from the UK BioSoil long term monitoring network plots will be summarised. Changes of shallow and deep soil carbon during early stage of forest planting, under different trees species and tree mixtures as well as through forest lifecycle assessed from Woodland Carbon Code scheme in the UK, long term monitoring networks, tree species experiments and across forest chronosequences will be reported. Soil carbon stocks and changes in time under natural colonisation as compared with planted woodland will be shown. The potential of agroforestry systems development in the UK to aid soil carbon sequestration will be demonstrated from a few case studies.

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Forest Research Technical Unit Support staff and Alice Holt laboratory for sampling and analysing soil samples over the many years of soil monitoring and research.

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GT 10 - 665 - O

THE USE OF DIFFERENT TYPES OF MANURE AFFECTS SOIL PARTICULATE ORGANIC MATTER FRACTIONS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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In organic farming, fertilization relies mainly on manure application. Due to the limited availability of fertilizers suitable for this type of agriculture, the soil ability to break down complex molecules plays a fundamental role in plant nutrition, as it is directly related with the efficiency of fertilizer use. Furthermore, it is crucial to consider the long-term effects when planning fertilization strategies. This long-term perspective not only benefits current yields but also ensures the sustainability of the soil and agricultural systems for the future.

A field experiment was carried out during six years. Four treatments were established with the application of different organic fertilizers (compost, chicken manure, cattle manure and pig manure) at the same nitrogen rate (170 kg N ha-1 yr-1). The rotation established in the trial was maize, pea and wheat, with manure application before maize and wheat sowing. After 6 years of the start of the experiment, the topsoil (0-0.2 m) was sampled and different organic matter (OM) fractions were determined according to their granulometry and density.

The organic matter in 2 mm-sieved soil was classified in three fractions from more to less labile: particulate organic matter (POM) which is comprised mostly by fresh residues and living organisms; humus organic matter (HOM) including physically protected residues, more resistant than the previous fraction; and the resistant organic matter (ROM) which includes the most stable portion of humus and charcoals.

The study revealed notable differences in soil organic carbon characteristics for the different fertilization treatments. HOM levels were particularly high in treatments where chicken manure or cattle manure had been applied, highlighting their efficacy in enriching soil in organic carbon, whereas treatments using compost and pig manure yielded lower HOM levels. POM was significantly diminished in soils treated with pig manure, setting it apart from the other treatments, as the mineralization rate was higher with this treatment than with the other fertilizers. ROM remained constant across all treatments.

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GT 10 - 669 - O

ORGANIC CARBON SEQUESTRATION POTENTIAL OF RUSSIAN CHERNOZEMS: A COMPARATIVE STUDY OF NET PRIMARY PRODUCTION METHODS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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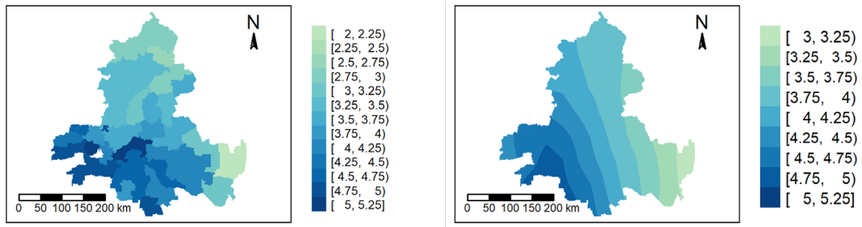
Introduction. Accurate forecasting of Net Primary Production (NPP) is crucial for estimating the uptake of organic carbon from plant residues into the soil, which is essential for dynamic modeling of carbon stocks in ecosystems.

Objectives and Methods. This study employs two distinct methods to calculate the NPP necessary for modeling soil organic carbon sequestration using the RothC model. The first method utilizes the MIAMI model, which estimates the flow of organic matter based on global climate data sources [2][4]. This model calculates NPP using Modis data, annual average temperature, and precipitation, providing an approximation of the territory's total natural potential for NPP production. The second method estimates NPP using actual statistics from Rosstat's municipal database, employing regression equations developed by Levin (1977) to estimate plant residue mass based on primary yield [3]. Data on sown area and yield were sourced from the Rosstat database, enabling the calculation of above-ground and below-ground crop biomass (see Fig 1 as example). Modeling was conducted at the level of second-tier administrative-territorial units with a spatial resolution of 1 km for the top 30 cm of arable Chernozem soils in selected regions of Russia (Rostov, Belgorod, Tatarstan, etc.) using special version of the RothC model [1].

Results and Conclusions. The study's findings indicate that Chernozem soils in the Rostov region exhibit a general pattern of decreasing carbon flows from southwest to northeast, with variations across districts. It was observed that Calcic Chernozems in accumulates fewer plant residues than previously assessed with MIAMI model, whereas Haplic Chernozems accumulate more. When applying the methodology based on local data, the average carbon sequestration factors shifted by 0.04 tons of C/ha per year. The distribution of sequestration rates within the region has also changed, with projected results indicating a carbon storage rate of up to 0.2 tons of C/ha per year over the next 20 years. The range of values increased by 15%, suggesting a more differentiated and individualized approach to assessing sequestration indicators at the municipal level.

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Net Primary Production (NPP, t C/ha per year) for Rostov region as example: on the left- data based on Rosstat data, on the right - data based on the MIAMI model



GT 10 - 701 - O

CARBON SEQUESTRATION AND AMMONIA ABATEMENT IN POULTRY AGROFORESTRY SYSTEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Reducing emissions from agriculture and increasing carbon sequestration are key challenges in creating more sustainable food production systems. In poultry farming, high ammonia emissions originating from housings are a major pollutant and a risk to surrounding environments exceeding their critical nitrogen load, leading to eutrophication, acidification and biodiversity loss across trophic levels. Agroforestry systems can be designed to deliver a wide range of benefits which help make agriculture more productive, provide ecosystem services and meet national targets. Studies have shown that mature woodlands close to poultry farms are able to scavenge atmospheric ammonia through their foliage and store it in their canopy and the soil [1]. A form of agroforestry, where trees are planted immediately outside livestock housing in a shelterbelt design, could therefore prove a powerful ammonia mitigation solution for farmers in addition to providing wider benefits such as carbon sequestration.

However, the effect of tree planting for ammonia scavenging on soils is unknown. This study provides new evidence on the impact of tree shelterbelts on soil properties at five poultry farms in Cumbria, UK. A mix of native broadleaves, conifers and fast-growing hybrid species were planted in 2009-2010 in the range of egg-laying hens. Soil sampling to 30cm depth was carried out 14 years later along transects from the housing, a point source of ammonia, up to 200 meters inside the shelterbelt, as well as adjacent pasture which represented the previous land use type. Soil organic carbon (SOC) was found to be higher inside the shelterbelt compared to pasture, but only significantly in the 15-30 cm soil depth ($p=0.04$). The proportion of active carbon of SOC was found to be significantly ($p<0.001$) higher in the pasture, suggesting that carbon is more stable under agroforestry, and thus contributing to carbon sequestration as well as stabilisation. Available nitrogen (specifically nitrate) in the soil and nitrous oxide (N_2O) flux declined with distance from the housings, likely due to increased nitrification activity near the farms.

To conclude, the results from this study show that poultry silvopastoral shelterbelts can increase SOC stocks in agricultural systems and buffer against negative effects from ammonia pollution, whilst improving overall soil quality. With the co-benefits of improved animal welfare and agronomic productivity, increased biodiversity and farm resilience [2], agroforestry and shelterbelts are important tools in sustainable land management.

ACKNOWLEDGEMENTS

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GT 10 - 711 - O

THERMAL, PARTICLE-SIZE AND MICROBIAL-AVAILABLE POOLS OF SOIL ORGANIC MATTER IN TILLED AND NO-TILLED CHERNOZEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Changes in soil organic matter (SOM) stability under different tillage systems are critical for developing effective agricultural management aimed at sustainable accumulation and conservation of soil carbon (SOC) stocks. Our study aimed to assess the effect of no-tillage on SOM stability in Chernozem topsoil (0–10 cm), determined by thermal, particle-size and biokinetic fractionation techniques. Soils was surveyed within working farms located in three regions of Russia: Samara (54.1°N, 50.3°E), Rostov (47.5°N, 38.9°E) and Krasnodar (45.0°N, 37.9°E). The listed regions have a temperate continental climate, with mean annual temperatures of 4.7, 10.9 and 13.1 °C, and precipitation of 459, 577 and 757 mm, respectively. In each region, 90 soil samples were collected in autumn 2022-2023 from three fields using long-term conventional tillage (CT; one field) and no-tillage for 5–14 yrs (NT; two fields). We used a model-based sampling design, i.e. conditioned Latin Hypercube sampling with a range of terrain covariates. Crop rotation in the Samara region included spring wheat, soybeans and sunflower; in the Rostov region – winter wheat and sunflower; in the Krasnodar region – winter wheat and corn. The thermal fractionation of SOM was based on analyzing the mass loss of soil samples during their gradual heating up to 650°C. According to the mass loss pattern, labile (200-400°C), stable (400-460°C), persistent (460-540°C) and refractory (540-600°C) pools of SOM were divided. The particle-size fractionation of soil dispersed by sonication at 60 J ml^{-1} was performed using wet sieving to isolate particulate (POM; 0.0531–2.00 mm) and mineral-associated organic matter (MAOM; <0.053 mm). The biokinetic technique was based on assessing the dynamics of cumulative CO_2 release from the soil during its six-month incubation at 22°C and 65% of field capacity. The microbial-available pool (C0) and its turnover time (1/k) were calculated using the one-compartment SOM model based on the first-order kinetics.

In the Samara and Rostov regions, NT relative to CT did not lead to significant changes in either SOM thermal stability or the microbial-available C0 pool. In contrast, NT tended to decrease SOM thermal stability and C0 content in the Krasnodar region. The particle-size pools (POM/MAOM ratio) did not show sensitivity to changes in tillage systems in all the considered regions. Principal component analysis revealed distinct regional variations in the quality of SOM. Specifically, the SOM of the Samara's Chernozems was more thermally labile, with a shorter C0 turnover time. In contrast, the SOM of the Rostov's Chernozems was more thermally stable, with a longer C0 turnover time. The SOM of the Krasnodar's Chernozems was found to differ markedly by the largest size of C0 pool relative to other regions.

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GT 10 - 797 - O

EFFECT OF MINIMUM TILLAGE AND NUTRIENT SUPPLEMENTATION TO INCORPORATED STRAW AND THEIR IMPACT ON SOIL ORGANIC MATTER AND STRUCTURE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Studies have reported the separate effects of minimum tillage and nutrient supplementation of incorporated crop residue, which improves soil organic carbon concentration, soil organic matter quality, and soil physical properties. However, it is unclear how these practices affect these properties when implemented simultaneously. A two-year field experiment was conducted to determine the effects of minimum tillage and nutrient supplementation of incorporated plant residue on soil organic carbon concentration and soil physical properties and their effect on soil organic matter quality. In this study, 3D imaging micro-computed tomography (µCT) was employed to study the effects of soil carbon change on soil structural change. Fourier-transform mid-infrared (MIR) spectroscopy was used to predict soil organic carbon and assess soil organic carbon quality. Soil organic carbon concentrations were estimated using a global MIR model, revealing a 0.36 wt % increase under minimum tillage compared to no change under conventional ploughing between the first and second years. The depth section 10-20 cm showed decreased porosity ($p < 0.01$), increased macroporosity ($p < 0.001$) and increased macropore density ($p < 0.005$) in relation to min-till treatment. Mid-infrared spectroscopy showed indications of a contribution to lignin-derived aromatic and aliphatic compounds. This, along with the improvement in soil macroporosity at the adjacent depth, suggests a possible enhancement in the fungal network and activity with minimum tillage practices. Although nutrient supplementation did not affect soil organic carbon concentration during the study period, positive changes in the mid-infrared spectra indirectly suggest a hypothesised change in the adsorption of aliphatic organic compounds to clay minerals. These findings highlight the importance of integrating chemical and structural analyses in understanding the mechanisms that drive soil carbon dynamics under conservation agriculture practices.

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GT 10 -799 - O

SYNERGIES BETWEEN CARBON DIOXIDE REMOVAL (CDR) APPROACHES FOR ECOSYSTEM BENEFITS FROM SOIL-BASED, HYBRID AND ENGINEERED METHODS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The rising concentration of CO_2 in the atmosphere driven by human activities is causing severe global socioenvironmental impacts, making large-scale Carbon Dioxide Removal (CDR) essential to keep global temperature rise below 2°C. Currently, there is a range of land-based CDR methods leveraging natural processes to enhance carbon sequestration in the soil. Conventional methods include, afforestation/reforestation, soil carbon sequestration, and peatland restoration. Novel CDR technologies, such as biochar, enhanced rock weathering and direct air capture, are accelerating natural processes through engineered interventions for carbon capture and long-term sequestration. This wide range of CDR approaches requires a more comprehensive understanding of the environmental and social constraints on CDR, ensuring that climate mitigation efforts do not compromise biodiversity, ecosystem services, or human well-being. In this context, robust scientific assessments are needed to evaluate monitoring, reporting and verification (MRV), co-benefits and impacts for all CDR technologies.

The EU-funded C-SINK project assessed the integration and potential for synergies in six key CDR technologies: Microbial CO_2 Fixation, Afforestation, Biochar, Artificial Soils, Bioenergy with Carbon Capture and Storage, and Enhanced Weathering. Given the novelty of CDR synergies, this work combines literature review, stakeholder insights, and structured methods, such as SWOT analysis and synergy evaluation matrices, to examine the feasibility and benefits of integrated deployment. C-SINK developed a detailed analysis of synergies between the project's target CDR technologies to enhance overall effectiveness and support EU climate goals. Due to the limited existing research on CDR synergies, the team collected expert input and project partner data to map potential interactions among the six technologies. Through structured methodologies, the study identifies integration pathways, mutual benefits, and potential conflicts. Key findings stress the importance of coordinated land-use planning, biodiversity protection, low-energy deployment, and supportive policy. This study also highlights the need for real-world pilot projects to generate data for combined applications, guiding future scaling and policy design.

Overall, CDR technologies offer strong potential to tackle climate change but face technical, economic, and environmental barriers. This study outlines recommendations to facilitate adoption of scalable synergistic CDR solutions, including regulatory frameworks, financial incentives for combined approaches, and advanced, data-driven MRV protocols. Exploiting these synergies will be vital to reaching Europe's net-zero targets and fostering long-term climate resilience.

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GT 10 - 813 - O

LAND USE INTENSIFICATION IN AMAZON REGION: IMPLICATIONS ON SOIL CARBON STORAGE AND STABILIZATION

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The expansion of agricultural lands into the Amazon region, followed by intensive tillage and extensive grazing, has often been associated with reductions in soil carbon (C) stocks. In the last decades, several sustainable land use intensification strategies have been implemented to restore degraded pastures and support agricultural development while minimizing deforestation. The adoption of well-managed pastures and integrated systems in the Amazon biome has marked a new transition, often characterized by increased soil C storage. Yet, the mechanisms behind the physical protection of soil C remain insufficiently understood. This study evaluated an 11-year field experiment to quantify changes in soil C storage and microbial attributes, as well as to identify the mechanisms of C stabilization in areas under anthropic uses in the southern Amazon region of Brazil. Four land use systems were assessed: crop succession (CS), integrated crop-livestock (ICL), integrated crop-livestock-forest (ICLF), and well-managed pasture (MP). Agricultural intensification by the integration of well-managed grass in ICL and MP systems led to higher soil C stocks in the top 10 cm, with values of 36.5 Mg ha-1 and 39.4 Mg ha-1 and accumulation rates of 0.68 Mg C ha-1 yr-1 and 0.95 Mg C ha-1 yr-1, compared to CS and ICLF. Increases in soil C stocks in the ICL and MP systems favored microbial activity, being positively correlated with greater microbial biomass C and enzymatic activity. These systems also improved soil aggregate stability, as shown by higher mean weight diameter and glomalin content than CS and ICLF. The higher presence of grass in MP and ICL systems was associated with increased mineral-associated organic carbon fraction, but particulate organic carbon was not affected by the land use systems. The X-ray photoelectron spectroscopy revealed that the MP system contained 11%, 38%, and 32% more recalcitrant C groups (aliphatic/aromatic) than ICL, ICLF, and CS at 0-5 cm layer, respectively. Our findings demonstrated that long-term systems incorporating well-managed grass, whether in MP or ICL configurations, enhanced soil C stabilization by favoring microbial activity, soil aggregation, mineral association, and chemical recalcitrance. These systems represent a promising strategy to enhance C storage in anthropized Amazon soils.

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GT 10 - 834 - O

SOIL CARBON STOCKS AND STABILITY UNDER EUROPEAN BEECH AND NORWAY SPRUCE STANDS IN DEPENDENCE ON PARENT MATERIAL

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The large-scale planting of Norway spruce (Picea abies [L.] Karst.) in Slovenia, as in much of Europe, outside its ecological niche in the past, led to current severe problems due to climate change and forest disturbances. The proportion of European beech (Fagus sylvatica L.) in growing stock is increasing, partly due to spruce mortality, adaptive forest management strategies, and the influence of large ungulates. Beech is expected to expand its natural range under future climate scenarios into forest areas that meet its ecological requirements, although its long-term resilience remains uncertain.

Tree species are known to influence soil organic carbon (SOC) stocks, and shifts in species composition may affect SOC dynamics. While differences in SOC stocks between spruce and beech, usually measured at fixed-depth intervals of up to 40 cm, have been documented, it remains unclear how these differences vary between soil horizons, in the subsoil and between different parent materials, especially with regard to SOC stability. This study focuses on two sites in Slovenia, one on siliceous (Pohorje area) and one on carbonate parent material (Snežnik-Javorniki plateau), both at similar stages of soil development and with the same forest stand species composition for over 50 years. Organic horizons (Ol and Of+Oh) were collected from four 25 × 25 cm plots within each of five stands per tree species at each site. Mineral soil was sampled by horizon throughout the entire soil profile in the same stands. Soil samples were analysed for basic physicochemical properties; organic (SOC), mineral (carbonate) and microbial carbon content; and subjected to physical fractionation to characterize mineral-associated organic carbon (MAOC) and particulate organic carbon (POC).

Results indicate that parent material has a greater influence on SOC stock in forest soils than tree species. SOC stocks were generally higher on siliceous than on carbonate parent material. No significant differences were observed between spruce and beech stands in SOC stocks of the organic horizons, A horizons, total mineral soil, or entire soil profile. Significantly higher SOC stocks were found in the B horizons of beech stands compared to spruce, but only on siliceous material, suggesting that tree species primarily affect the vertical distribution of SOC rather than total SOC stocks. Nonetheless, differences in litter quality may still influence SOC stability. Results from the physical fractionation analysis (MAOC, POC) will be presented at the congress.

GT 10 - 997 - O

THE IMPACT OF NO-TILLAGE ON ORGANIC CARBON IN DEEP ROOT-INDUCED SHEATH SOIL WITHIN NORTHEAST CHINA MOLLISOLS AND ANALYSIS OF STABILIZATION MECHANISMS

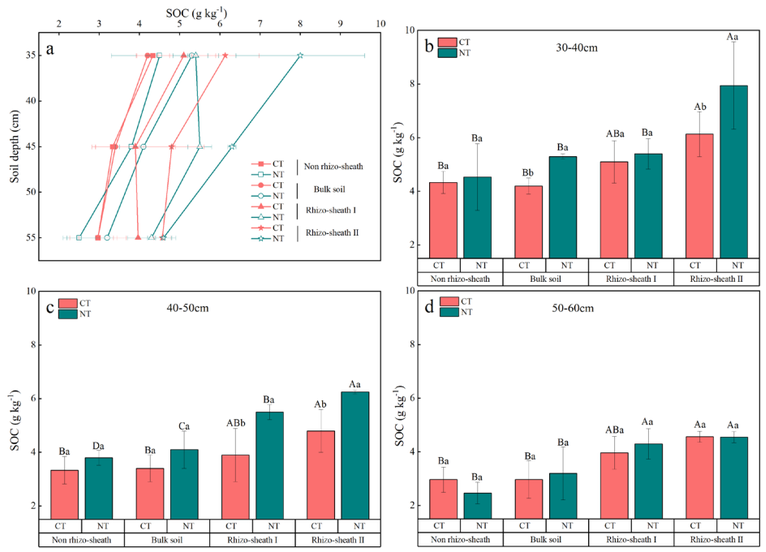
GT 08. SOIL-PLANT-WATER INTERACTIONS / GT 02. SOIL PHYSICAL CHEMISTRY

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No-tillage (NT) can effectively increase soil organic carbon (SOC) in the surface layer (<30 cm); however, its impact on deeper SOC (>30 cm) remains inconclusive. In deep soil, heterogeneity in pore distribution forms carbon-enriched "hotspots" – specifically, the biopore sheath soil (soil within 2 mm of biopores). Traditional mixed sampling methods (without distinguishing sheath soil from non-sheath soil) may obscure treatment effects. In this study, we investigated deep soil (30-60 cm) under long-term conservation tillage (10 years) in a Mollisol. Intact soil columns were collected from NT and conventional tillage (CT) plots and subdivided into biopore sheath soil and non-sheath soil zones. We employed ^{13}C stable isotope analysis, Fourier Transform Infrared Spectroscopy (FTIR), and thermogravimetric analysis (TGA) to explore the effects of NT on deep SOC content, origin, and composition in biopore sheath soils. Root density, specific surface area (SSA), and contact angle (CA) were also measured to analyze SOC stabilization mechanisms from dual perspectives: carbon input and physical protection. Results revealed that in the 30-50 cm layer, SOC content within biopore sheath soil under NT was significantly higher (30%-40% increase, $P<0.05$) compared to CT, emphasizing the necessity of microzone-specific sampling for accurately evaluating NT's deep SOC sequestration potential. ^{13}C showed significantly higher $\delta^{13}C$ values (-18.87‰) in the NT sheath soil compared to CT (-19.52‰, $P<0.05$) at 30-50 cm, indicating greater input of recent carbon under NT. This recent carbon primarily originated from roots. NT significantly increased the proportion of roots utilizing pre-existing biopores (+36% to +105%), enhanced root density (25%-33%), and consequently promoted root-derived carbon input (reflected by $\delta^{13}C$). Post-input, root-derived carbon was predominantly present as aliphatic C. NT sheath soil exhibited significa tly higher aliphatic C content than non-sheath soil ($P<0.05$), and this more labile SOC was predominantly stabilized within micropores (<2 nm). Additionally, the contact angle in NT sheath soil was significantly higher than under CT ($P<0.05$), indicating enhanced hydrophobicity. This increased water repellency accelerates water flow, reduces soil-water contact time, and thus minimizes the dissolution and loss of soluble organic carbon. This study provides novel insights into NT's deep SOC sequestration mechanisms and underscores the critical role of biopore sheath zones, highlighting the necessity of zone-specific sampling



GT 10 - 174 - F + P

WINTER COVER CROPS IMPROVE SOIL ORGANIC CARBON AND AGGREGATION IN MEDITERRANEAN RICE SYSTEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Mediterranean rice (Oryza sativa L.) systems are increasingly threatened by soil degradation, exacerbated by monocropping, intensive tillage practices and excessive reliance on agrochemicals. Cover crops (CC) have shown potential in improving soil quality in other cropping systems, particularly by enhancing soil organic carbon (SOC). However, their role in Mediterranean rice production remains underexplored. This research assessed the effects of winter cover crops on soil organic carbon (SOC) dynamics and soil physical properties in a rice field experiment conducted over a three-year period in the Ebro Delta (NE Spain). Treatments combined three winter management options—annual ryegrass (Lolium multiflorum Lam.), hairy vetch (Vicia villosa Roth), and dry bare fallow—with nitrogen (N) fertilizer application to rice (0 and 180 kg N ha^{-1}). Preliminary results indicate that both CC species improved SOC concentrations in the topsoil compared to bare fallow, mainly through increased particulate organic matter. Ryegrass induced earlier effects while hairy vetch contributed progressively through increasing biomass inputs. Topsoil aggregation was also improved, potentially via ryegrass root action and hairy vetch benefits to N availability and rice residue production. Despite limiting conditions for biomass accumulation, winter CC were shown to improve soil quality in a Mediterranean rice system within a relatively short timeframe. Greater benefits to soil quality and carbon sequestration may be achieved through prolonged implementation and complementary practices that enhance CC growth and residue inputs.



GT 10 - 313 - F + P

ENHANCING CARBON SEQUESTRATION IN ITALIAN SOILS THROUGH REGENERATIVE AGRICULTURE: A REGIONAL COMPARATIVE STUDY

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Soils are increasingly recognized as critical reservoirs for carbon sequestration, with significant implications for climate mitigation strategies. This study evaluates the carbon sequestration potential of soils in farms located in three Italian regions; Molise, Sardinia, and Lazio under regenerative versus conventional agricultural practices. Regenerative practices increased overall total organic carbon (TOC) in the soil samples to 55.69 % as compared to conventional practices. Carbon fractionation further revealed that in the <53 µm fraction, typically associated with persistent organic carbon, regenerative practices exhibited 51.81% higher TOC concentration relative to conventional practices, suggesting enhanced long-term carbon stabilization. By accounting for regional variability in climate, soil type, and management practices, this work offers robust, spatially explicit evidence that regenerative farming substantially improves soil carbon stocks in Mediterranean environments. These findings underscore the potential of targeted land management strategies to enhance soil health and contribute meaningfully to climate change mitigation efforts across Europe.

GT 10 - 564 - F + P

LEGUME COVER CROPS AND NON-TILLAGE ENHANCE SOIL MICROBIAL FUNCTIONAL DIVERSITY IN A SEMI-ARID BARLEY SYSTEM UNDER SUMMER RAIN PULSES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Rain water pulses in semi-arid systems trigger peaks in soil microbial activity that enhance nutrient mineralization and directly influence carbon (C) cycling. Understanding how contrasting agricultural management systems in semi-arid regions respond to water pulses is essential to evaluate agroecosystems functioning and predict C dynamics.

In this study, we monitored the effects of summer rain pulses on soil microbial activity in the fallow period of contrasting barely (Hordeum vulgare) based management systems in a semi-arid region of Spain. The tested management systems included: i) a traditional cropping system with one season of barley followed by 16-18 months of tilled fallow (Barely-Tilled Fallow), ii) a no-till system of barley followed by 16-18 months of chemical fallow (Barley – Chemical Fallow) and iii) a no-till system of barely/vetch (Vicia sp.) rotation with 6 months of chemical fallow between each crop (Barley-Vetch). A randomized complete block design was used, incorporating both phases of each crop rotation simultaneously.

Microbial activity was assessed by characterizing the microbial catabolic profile using substrate induced respiration (MicroResp™) across a range of carbon substrates. Soil bacterial and fungal biomass were quantified via qPCR targeting 16S rRNA and ITS genes. Additionally, soil pore water content, available mineral nitrogen, and labile carbon fractions were analyzed.

Preliminary results revealed clear differences in soil microbial functionality across management systems. The Barely-Vetch rotation consistently showed higher substrate induced respiration particularly for labile carbon sources (glucose, citric acid, N-acetyglucosamine), indicating enhanced microbial functional diversity and resilience during summer periods. In contrast, microbial activity in the Barely-Tilled Fallow system was significantly lower, indicating reduced microbial functionality.

Our results demonstrate the detrimental effects of physical soil disturbance on microbial functional diversity, and highlight the positive influence of legume cover crops and reduced tillage on maintaining microbial functionality under fluctuating soil moisture conditions



GT 10 - 605 - F + P

SOIL STRUCTURE FORMATION MEDIATED BY ORGANIC MATTER AND SHORT-RANGE ORDER ALUMINUM PHASES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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The long-term persistence of soil organic carbon (SOC) is influenced by a complex interplay of physical, chemical, and biological properties of the soil. The spatial arrangement of solids and voids, that is, the soil structure, determines the oxygen supply and accessibility of SOC to microbial decomposition. In turn, the interactions between soil organic matter and the soil mineral phase govern the soil structure. Among soil minerals, short-range order aluminum phases, such as imogolite, contribute to the chemical stabilization of organic matter. Although these mechanisms are individually well understood, the complex interactions of physical protection and chemical stabilization are less studied. We conducted a lab incubation experiment to investigate how a combination of short-range aluminum mineral phases and different types of organic amendments affect structure formation and soil organic matter mineralization. We gently crushed soil fragments of an arable soil and mixed with synthetic imogolite and a source of organic carbon, which was either straw (with size of 0.5-1 mm, 6.6 mg/g) or mucilage (0.05 mg/g and 0.5 mg/g). The soil was then packed into cylindrical soil columns (height 2.5 cm and width 2.1 cm) and incubated for 60 days at 20°C in the dark, with repeated wetting-drying cycles and recording of CO2 emissions after 10 days of incubation time using an NaOH-solution trap. Before and after incubation, the pore network was analyzed using 3D X-ray micro-computed tomography. At the end of the incubation, chemical and biological soil properties were analyzed. Compared to the control, imogolite-amended soil had lower SOC-specific respiration rate, regardless of the type of organic matter source. For instance, the presence of imogolite reduced SOC-specific respiration rates of straw-amended soil by almost half as compared to the control treatment with straw-amendment (and 1187 µg CO2–C g−1 h−1 vs 2080 µg CO2–C g−1 h−1). Imogolite additions also led to a smaller visible porosity, suggesting a lower aeration within the soil. The reduced carbon mineralization by imogolite is likely a combined effect of chemical stabilization and physical protection. The mucilage amendment resulted in higher visible porosity compared to straw, but lower respiration rates, possibly reflecting the gluing and hydrophobic properties of mucilage, which made organic matter inaccessible to microbial decomposition. The synergistic effects on soil structure of aluminosilicates and organic matter dynamics underscores their importance in sustainable soil management and climate change mitigation strategies.

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GT 10 - 839 - F + P

EVALUATION OF DECISION SUPPORT TOOLS FOR THE ESTIMATION OF SOIL CARBON STOCK CHANGE UNDER SUSTAINABLE SOIL MANAGEMENT PRACTICES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Decision Support Tools (DSTs) that estimate soil carbon sequestration support farmer decisions on soil management for enhanced sustainability. This study aims to test the accuracy of DSTs to estimate soil carbon sequestration under sustainable soil management practices using data from two experiments. The four DSTs, identified are suitable for estimating soil carbon stock in European cropping regions and are accessible as open-source software or through sustainability schemes, specifically: The Farm Carbon Calculator, the Environmental Externalities ACcounting Tool (Ex- ACT), the Solagro Carbon Calculator, and the Cool Farm Tool. The Farming and Tillage Systems Experiment (FAST) at Agroscope, Switzerland, implements a 6-year crop rotation and evaluates the influence of farming systems (organic versus conventional), reduced tillage, and cover cropping. The Cereals, Organic Manures and Soils (COMS) experiment at the Agri-Food & Biosciences Institute (AFBI) Crossnacreevy Plant Testing Station in Northern Ireland grows continuous spring barley under various types of organic fertilisation ranging from cow slurry, pig slurry, to digestate with and without an inorganic dressing at 90 kg N ha-1 yr-1.

A preliminary test was conducted using a sample data. This represented continuous winter wheat (1 ha), soil organic matter 5.16 to 10.32%, Cambisol soil type, fine clay soil texture, soil pH 5.5 to 7.3, mineral fertiliser NPK 15:15:15 applied at 74 kg/hectare, reduced tillage, high residue input, altitude 486 m and a moist cool temperate climate. Soil carbon sequestration estimated by each of the DSTs varied as 0, 0.27, 0.51, and 0.66 t C ha-1 year-1 from the Farm Carbon Calculator, Ex-ACT, Solagro Carbon Calculator and Cool Farm Tool, respectively. The Farm Carbon Calculator was excluded from further analysis. Evaluation of annual soil carbon stock change during the last completed 6-year rotation in the FAST experiment across all treatments ranged from -0.68 to 3.4, 0.00 to 2.05, and from 0.00 to 1.62 t C ha-1 year-1 as estimated by the EX- ACT Tool, Solagro Carbon Calculator and Cool Farm Tool, respectively. This indicates an overestimation of the 6-year cumulative soil carbon stock change, ranging from 1.516 to 8.650 t C ha -1 across all treatments, compared to the observed cumulative soil carbon change over the same period. Variation in the estimates is likely due to differences in the calculation of the baseline carbon stock, data inputs, and the IPCC tier applied in the structure of the DSTs. Model developments to incorporate multi-year assessment and improved baseline soil carbon stock estimation are underway, with new versions of the DSTs due for release in 2025. This study will use the updated DSTs in further work to estimate soil carbon stock under sustainable soil management using data from the FAST and COMS long-term experiments.

ACKNOWLEDGEMENTS

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GT 10 - 12 - P

THE STABILIZATION OF SOIL ORGANIC MATTER INFLUENCED BY SELECTED TREE SPECIES IN A TEMPERATE CLIMATE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The composition of tree species in a forest stand significantly influences the biophysicochemical properties of soil. This study aimed to explore the relationship between the fractional composition of soil organic matter (SOM) and the composition of soil leachates under the influence of different tree species. We hypothesized that SOM fractions are strongly positively correlated with dissolved organic carbon (DOC), nitrogen, and the ionic composition of leachates. The research was conducted in a common garden experiment involving eight tree species and examined the vertical variability of SOM fractions in relation to leachate composition. The study focused on the organic horizon (O), humus mineral horizon (A), and enrichment horizon (B). Our findings confirmed that the species composition of the forest stand distinctly affects the quantities of light and heavy mineral-associated SOM fractions. Tree species significantly influenced the levels of DOC, pH, and concentrations of specific cations and anions in leachates across different soil horizons. The content of carbon (C) and nitrogen (N) in SOM fractions, along with the ionic composition of leachates, varied with soil depth. Labile and stable fractions of C and N were strongly positively correlated with DOC and nitrogen in leachates. Deciduous species such as Norway maple, sycamore maple, and small-leaved lime emerged as favorable options for promoting organic matter stabilization. These findings have practical implications for selecting tree species in forest stand management, particularly in the context of changing climate conditions.

ACKNOWLEDGEMENTS

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GT 10 - 15 - P

EFFECTS OF NUTRIENT-ENRICHED BIOCHAR ON SOIL PHYSICOCHEMICAL PROPERTIES AND GREENHOUSE GAS EMISSIONS OF A NUTRIENT-DEFICIENT SANDY LOAM

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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The use of biochars in agricultural soils is increasingly being studied for its potential to improve soil properties and enhance crop yields (Palansooriya et al. 2019, Vijay et al. 2021), while simultaneously mitigating greenhouse gas emissions (Borchard et al. 2019, Zhang et al., 2023). Nutrient enrichment of biochars using various activation techniques has been proposed to add value to pure biochars due to improved nitrogen availability (Pathy et al. 2021). Data regarding the effects of nutrient-activated biochars in boreal regions is currently unavailable. Most biochar experiments have been short-term (1–6 years). Additionally, studies involving biochar reapplication in the same field are few or non-existent. Our capacity to definitively determine the impacts of biochar on soils is hampered by the absence of long-term (i.e., more than five years) and biochar reapplication experiments. This study aims to establish the best practices for using biochars in boreal soils by investigating how nutrient-enriched biochars combined with different fertilizer strategies will affect soil physicochemical properties, greenhouse gas emissions, and yield formation in barley, faba bean, and spring wheat, on a nutrient-deficient Finnish soil.

To evaluate these effects, a biochar reapplication study was conducted on Umbrisol soil with a loamy sand texture at the Viikki experimental farm at the University of Helsinki, Finland, using a biochar treated first with nitric acid (HNO3) and then with cattle slurry mixed with Agra 13:0:0 organic fertilizer. The first biochar application was in 2011 (Tammeorg et al, 2014) using a split-plot experimental design in four replicates with pure spruce biochar applied at 0, 5, 10, 20, and 30 Mg/ha. In May 2023, 15 Mg/ha and 30 Mg/ha of freshly nutrient-activated biochars were added to the original 5 Mg/ha and 20 Mg/ha plots, respectively, and a three-year crop rotation of barley (2023), faba bean (2024), and spring wheat (2025) was commenced.

A closed chamber technique, involving pairs of metal cylinder chambers is applied to collect greenhouse gas samples eight times during the growing season from plots with the most extreme biochar treatments (0 and 30 Mg/ha). On sampling, a 2 × 5 ml gas sample is drawn (one from each chamber) with a syringe and injected into an evacuated gas vial at specified times (0, 20, and 40 min) after closing the chambers to give a total of three samples for each plot on each sampling date. The amounts of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) from the collected gas samples are determined by gas chromatography using Agilent GC (7890A, Agilent Technologies, Santa Clara, USA) in the Environmental Soil Science Unit, Department of Agricultural Science (ESS DAS).

Soil moisture is monitored weekly by time domain reflectometry (TDR) (HandiTrase, California, USA) on plots with the most extreme biochar treatments (0 and 30 Mg/ha) in three different layers (0-15 cm, 0-28 cm, and 0-58 cm). There was no soil sampling before sowing, except for 2023 when biochar was reapplied. A commercial soil testing laboratory (Hortilab Oy, Finland) will analyze all soil samples for plant-available nutrients. Soil total carbon and nitrogen content will be determined using Leco CN analyzer (Leco Corporation, Michigan, USA) in the Department of Forestry. The treatment effects on soil water retention curve, bulk density and porosity will be analysed from the structural soil samples taken in the autumns of 2023 and 2025. In the plots for gas emission measurements, soil samples are taken from topsoil (0-20 cm) on each gas emission sampling. For the determination of soil mineral nitrogen, a subsample about 20 g of fresh, cleaned (not sieved) soil was extracted with 25 ml 2.0 M KCl, shaken for 120 min in a shaker, then centrifuged at 3000 rpm for 15 mins and later filtered through Whatman™ 589/3 folded filters (diameter 150 mm) and stored frozen (–20°C) before measuring with an automated discreet analyzer Gallery Plus ECM (Thermo Fisher Scientific, Massachusetts, United States).

Preliminary results on soil moisture contents tentatively indicate that the addition of nutrient-enriched biochar slightly increased the soil moisture content in the upper soil layer (0 – 18 cm layer). A similar pattern was observed also in the deeper layer (0 - 58 cm). Future statistical analyses will ascertain their significance. The results on the effects of nutrient-enriched biochars on greenhouse gas emissions and soil physical and chemical properties will be presented in more detail in the poster.

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GT 10 - 32 - P

CHANGES IN THE ORGANIC CARBON CONTENT OF SOILS IN FORMER MINE BARREN AREAS COVERED WITH FORESTS OF DIFFERENT AGES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 04. SOIL BIOLOGY

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During our research, we investigated how quickly the organic carbon entering the inert material through the litter production and root materials of the trees after afforestation is incorporated into the resulting soils in the case of acacia forests planted in reclaimed areas of different ages in the reclaimed area of an open-pit coal mine near Bükkábrány, Hungary.

The research area is located in the northeastern part of Hungary.The annual mean temperature is 10 °C, while the annual mean precipitation is approx. 590 mm.

During the studies, we examined the soils of 5, 13, 18, 23 and 29-year-old white acacia (Robinia pseudoacacia) forests. We used a 20 mm diameter Pürckhauer 434 1175/1000 mm (Bürkle GmbH) soil sampler, with which we took soil samples from depths of 0 – 5, 5 – 15 and 15 – 25 cm, from 5 – 5 boreholes randomly per forest site. A CN analyzer (Skalar Primacs Snc-100 CN) was used to examine the samples. One-Way randomized design ANOVA and “Tukey” HSD test were used in the statistical analyses.

Analysis of the top 25 cm of the soils in 3 layers showed a significant increase in organic carbon and nitrogen content. However, the extent of this increase differed significantly at different depths and periods, but overall we experienced a 4-8-fold increase over 24 years. This shows that the almost organic matter-free sediment cover has already retained a significant amount of organic matter for a quarter of a century. In the top 5 cm layer, the carbon content reached 4%, but even in the bottom 15-25 cm layer it was 1.1%. In the case of the upper 5 cm layer, both the carbon content and the nitrogen content reached the equilibrium state characteristic of the given forest type in terms of carbon content, so they did not increase after the 23rd year.

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GT 10 - 41 - P

SOIL ORGANIC CARBON MAPPING IN THE NEVĖŽIS PLAIN: ANALYZING SPATIAL VARIABILITY AND INTERPOLATION TECHNIQUES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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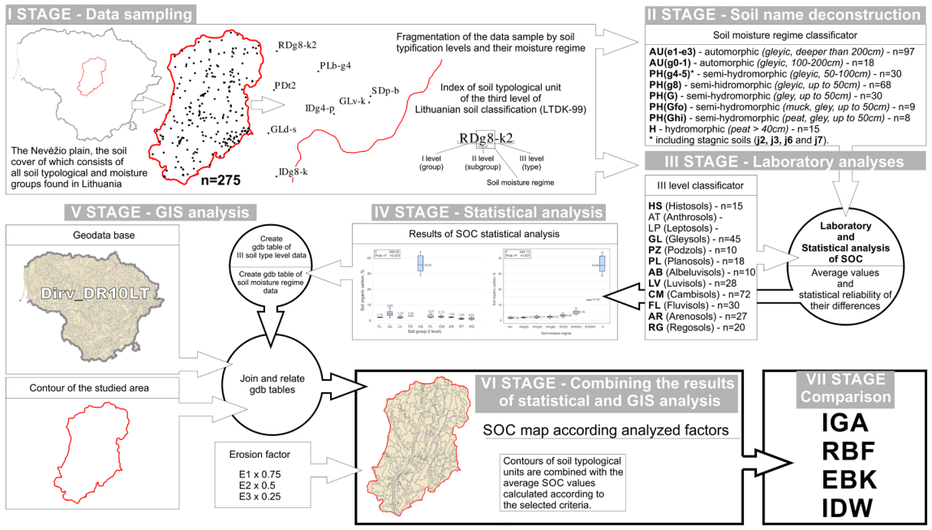
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Soil organic carbon (SOC) is a key indicator of soil quality and health and plays a direct role in agricultural productivity. Therefore, SOC is essential for assessing the long-term sustainability of soil management practices. This study investigates the spatial distribution and mapping of SOC in the Nevėžis Plain, Lithuania, utilizing various interpolation techniques. The research specifically examines how soil typological units, moisture regimes, and erosion influence SOC patterns. A total of 275 soil samples were collected from agricultural fields at a depth of 0–10 cm, supplemented by 38 samples from previous studies. The SOC mapping was conducted using the contour framework provided by the Lithuanian soil geodatabase. Statistical analysis demonstrated that SOC distribution in the study area is significantly affected by soil moisture levels and erosion intensity. The study found that commonly used interpolation methods exhibit limitations: kriging, RBF, and EBK struggle to accurately represent the extreme SOC values, while IDW primarily underestimates the minimum values. Overall, this geographically integrated approach (IGA), although complex, proves to be a viable method for SOC mapping. To enhance future SOC mapping efforts, key methodological principles should include ensuring a statistically robust dataset, categorizing samples by distinct soil moisture regimes, erosion levels, and land use types, and developing contouring criteria alongside an algorithm that supports accurate spatial interpolation of average SOC values.

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GT 10 - 67 - P

SOIL ORGANIC CARBON OF DIFFERENT GEOMORPHOLOGICAL UNITS OF VOJVODINA PROVINCE, SERBIA

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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The province of Vojvodina is located in the north of the Republic of Serbia and the south of the Central European Pannonian basin - coordinates of the geographic center - 45º24'05" N, 20º04'53" E. It is a distinct agricultural area with over 80% of arable land.

In the research, over 1,300 soil samples were sampled up to a depth of 30 cm, according to a regular grid with a sampling location distance of 4 x 4 km, each sample representing an area of 16 km2 (the grid was established with the help of GIS tools - GIS ArcView 10). Geomorphological units (mountains, sandy terrains, loess plateaus, loess terraces and alluviums) were determined based on geomorphological maps of Vojvodina [1] [2]. The largest part of the surface of Vojvodina is occupied by loess plateaus and loess terraces. The mountains in Vojvodina are low: Fruška Gora - peak 539 m above sea level and Vršačka Planina - peak 641 m above sea level. The alluviums are along the rivers Danube, Sava Tisza and its smaller Carpathian tributaries. Soil organic carbon was determined by the method of oxidation of organic matter according to Tyurin.

The highest, and almost identical, average soil organic carbon content was recorded in soil samples from loess plateaus (1.85%) and loess terraces (1.84%). The content is lower in samples from alluviums (1.72%) and mountains (1.60%). The lowest content is in sandy terrains samples (1.17%). A statistically significant difference was found between all geomorphological units, except between loess plateaus and loess terraces. This is expected considering that these two geomorphological units have the same parent substrate (loess) and organic world (meadow steppe vegetation) as dominant pedogenetic factors in Vojvodina. The values of SOC content from alluvium and mountains, where different parent substrates influenced equally low values, are also without statistically significant differences.

The significance of the work is the importance of knowing the impact of various geomorphological units and pedogenetic factors on soil organic carbon content values, as one of the most important agronomic indicators of soil fertility. Considering the age of the data used, the paper points to the necessity of determining their reliability as well as possible changes in relation to today's state.

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GT 10 - 77 - P

ASSESSMENT OF BIOCHAR AS SOIL AMENDMENT: IMPACT ON SOIL ORGANIC CARBON THROUGHOUT A MEDIUM-TERM INCUBATION EXPERIMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The application of biochar as soil amendment has been shown to enrich the soil with stable forms of organic carbon, thereby increasing its carbon content (SOC). However, the organic sources of biochar can have a different behavior not only on the carbon stocked in the soil but also on its content over time. The aim of this work is to assess through an incubation experiment the effect of six different biochars on the amount of SOC and its content changes over 126 days. The experimental design was completely randomized with seven treatments, each one with three replicates. Each pot was filled with 55 g of biochar/kg of soil and incubated at 23 ºC. Five biochars (B1 to B5) were derived from the pyrolysis at different temperatures of various proportions of poultry manure (PM) and date palm fronds (DPF). B1 was derived from a mixture of 50% PM and 50%DPF. For B2, the proportion was 45%, and 10% of calcined marble was added, while B3, B4 and B5 the proportion was 37.5% with 25% of calcined marble. The pyrolysis temperature was fixed to 500 °C for B1, B2 and B3, 400 °C for B4, and 700 °C for B5. B6 was produced from wood material at 700 °C. A control treatment (CT) without biochar application was also carried out.

The findings demonstrate that all biochars significantly increased SOC compared with CT (Fig.1).

Additionally, it is possible to observe that the values for some biochars increased over time. CT values varied from the first sample date 18.5 to the last sample 20.0 g/kg, B1 from 34.9 to 38.4 g/kg, B2 from 29.7 to 36.0 g/kg, B3 from 26.6 to 30.0 g/kg and B6 from 39.1 to 42.3 g/kg. However, in B4 and B5 a slight decrease was observed through the incubation period. In B4 the SOC varied from 29.2 to 28.6 g/kg and in B5 from 28.1 to 27.7 g/kg. Indeed, B4 and B5 differ from B3 only in the pyrolysis temperature, from B1 and B2 differ on the proportion of the organic sources ant pyrolysis temperature and from B6 differ on the organic source and for B4 also in the pyrolysis temperature. The results highlight how different organic sources and the pyrolysis temperature used to produce biochar affect soil carbon content and evolution.

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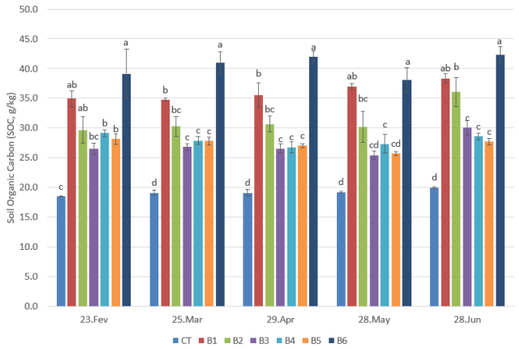


Figure 1: Changes of Soil Organic Carbon (SOC, g/kg) content throughout the incubation experiment.

GT 10 - 87 - P

DISCOVERING THE MOLECULAR BASIS FOR CARBON STORAGE IN SOIL FOR FOOD SECURITY AND CLIMATE CHANGE MITIGATION

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil organic carbon (SOC) is a fundamental component of the global carbon cycle, acting as both a major carbon sink and a key determinant of soil health. Thus, it is crucial to understand how carbon storage in soils is controlled. Recent studies suggest that long-term SOC persistence is primarily regulated by microbial accessibility rather than intrinsic chemical recalcitrance of different compound classes. However, the physico-chemical mechanisms protecting various SOC compounds and the limits of soil stabilisation capacity remain unclear. If such limits exist, that will constrain the potential of land management to increase SOC storage, while the current key SOC models, such as Rothamsted C model (RothC), do not incorporate these factors.

This study combines physical fractionation methods which separate soil aggregates and mineral-protected pools, with advanced compound-specific radiocarbon analysis (CSRA) to directly determine the residence time of different SOC compound classes. By utilising well-controlled modern and historical soils from Long-Term Experiments at Rothamsted Research (RRes), we aim to understand how different SOC compounds are stabilised, assess whether soils have a maximum capacity for carbon storage, and refine the RothC model to improve predictions of SOC sequestration, which will enhance land management strategies for long-term carbon storage



GT 10 - 89 - P

A GLOBAL MODEL OF TREETHROW FORMS AND THE ROLE OF TREE MORTALITY IN SOIL CARBON STORAGE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Each of the 3.04 trillion trees on Earth is involved in the evolution of soils, soil deepening and erosion. Trees naturally regenerate, and in many ecosystems, a significant type of tree mortality is uprooting. As a result of climate change, the disturbance regimes of forests are also changing, and tree uprooting can potentially be even more significant in many regions than before. However, we still do not know how tree uprooting affects C storage in soils. In the research we analyse exceptionally extensive data from repeated tree censuses and measured uprooting structures on research plots in old-growth tropical and temperate forests. We categorize disturbance regimes and subsequently look for general relationships between soil chemistry (especially C content) and their long-term mechanical disturbance. During the experiment in two contrasting soil regions (Cambisols and Podzols in the temperate zone), we use a detailed microbiological and physico-chemical approach to determine the causal relationships between the mechanical disturbance of soils by uprooting and the C cycle in soils.

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Uprooted trees after Herwart storm in Sumava Mts, Czech Republic, in 2017

GT 10 - 98 - P

UNRAVELING SOIL ORGANIC CARBON CONTENT FROM MID-IR SPECTROSCOPY WITH THE BOUGUER-BEER-LAMBERT LAW AND NONNEGATIVE MCR APPROACH

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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We propose an innovative approach for modeling soil organic carbon (SOC) content, employing the classic Bouguer-Beer-Lambert (BBL) law for a mixture of unknown components coupled with the nonnegative multivariate curve resolution (MCR) of soil mid-IR spectra. Soil IR spectroscopy is widely recognized as a tool to model and predict SOC contents, yet with the use of diverse multivariate empirical models. Although a significant success is achieved in modeling SOC contents, the interpretation of these models is not straightforward. Conversely, the use of the nonnegative MCR presents an opportunity to build an interpretable physico-chemical model linking the SOC content with soil constituents, their fractions, and intrinsic SOC capacities. The decomposition of soil IR spectra into the contributions of these soil constituents is possible due to the ability of nonnegative MCR to identify major soil components that control the IR spectra. Based on the nonnegative MCR of soil IR spectra, a simple BBL law-following model has been developed [1] and applied to examine SOC contents in a series of soil samples taken from different depths and under different land uses in different regions of Israel. The MCR decomposition of soil mid-IR spectra allowed the identification of a soil component enriched by carbonates as well as organo-mineral associations [which may reflect both physico-chemically interacting components and/or mixtures maintaining constant compositions in a series of samples]. The four MCR components identified in the 213 soil samples accounted for 99,7% of soil mid-IR spectra variability. Eventually, SOC content below 1.0% w w-1 was modelled with RMSD comparable with that reached by a partial least squares regression model. However, the MCR-BBL model failed to model SOC contents >1.0 %. The identified threshold in the model efficacy is currently considered as an estimate for SOC tightly linked to soil minerals; above this threshold, soil organic matter (SOM)-mineral interactions become essentially weakened (if at all). The developed approach provides an original way to distinguish between different SOM types, which is of great interest in soil biogeochemistry. This may help understand SOM stabilization due to its interactions with minerals and the role in those of SOM chemical composition. Nevertheless, the following challenges still remain: (i) understanding the reasons for the failure of the nonnegative MCR analysis, that provides a full representation of soil IR spectra and adheres to the BBL law, to model high SOC contents, and (ii) the search for tools that could overcome this failure.

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GT 10 - 128 - P

SOIL MICROBES AND THE CARBON TO NITROGEN RATIO INDICATE PRIMING EFFECTS ACROSS TERRESTRIAL ECOSYSTEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The control of the exogenous carbon-induced soil-priming effect (PE) by soil microbes, carbon, nitrogen, and carbon/nitrogen is still uncertain. To examine the relationship between diverse soil properties and the PE, the research was conducted using soils from forest, cropland, and grassland ecosystems.

We introduced a solution of 13C-labeled glucose (containing 6 atom% 13C) into soils collected from three distinct ecosystems. For the control group, we added an equal amount of water to the soils. Subsequently, all treatment and control samples were incubated at 60% of their water holding capacity and maintained at a temperature of 25°C for a period of 28 days.

The magnitude of priming on native SOC was significantly higher in grassland ecosystems than in forest and cropland ecosystems. The results of structural equation modelling revealed a significant positive association of the PE with the soil carbon/nitrogen ratio, bacterial diversity, and community composition, as well as a negative association of the PE with SOC, dissolved organic carbon, and total nitrogen. Network analysis showed that the keystone taxa for each ecosystem were different. Sphingomonas, SBR1031, BD2-11-terrestrial-group, and Sebacina were the keystone taxa significantly positively associated with the PE, whereas Solirubrobacter, Bacillus, and Preussia were the keystone taxa significantly negatively associated with the PE.

Our findings are significant for studying carbon fluxes, improving soil carbon dynamics models, and understanding soil microbe, carbon, and nitrogen relationships with SOC mineralization. This understanding is crucial for mitigating climate change, promoting sustainable land management, and enhancing soil carbon stabilization.

KEYWORDS

Soil organic carbon mineralisation, exogenous carbon input, microbial community composition, terrestrial ecosystems.

Soil microbes and the carbon to nitrogen ratio indicate priming effects across terrestrial ecosystems.docx

GT 10 - 135 - P

CHARACTERIZING STABILITY AND DYNAMICS OF ORGANIC MATTER IN WORM COMPOST USING ROCK-EVAL® ANALYSIS - PRELIMINARY RESULTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Numerous questions are pending on the role of soil engineers on the organic matter evolution in soil and more generally on the complete biochemical cycle of the carbon. Worm compost, used to enrich the soil with organic compounds, improves soil structure and fertility. As a characteristic product of soil engineers, it is then of high interest to study.

Rock-Eval® thermal analysis allows to quantify the C-H bonds in the organic matter (OM) of a sample through controlled open-pyrolysis. Relying on the hypothesis that thermal stability can serve as a proxy for biogeochemical stability, such analysis is nowadays commonly used to characterize OM in soils (Sebag et al. 2006; Albrecht et al. 2015; Sebag et

al. 2016) or to assess the impact of worms on organic matter (Ducasse et al. 2023) both at a field and meso-scales (such as a flower-pot). However, no experimental study exists using a commercial worm composter. In many commercially available worm composters, the trays are periodically rotated downward over the composting time. This action raises the question of whether it is possible to track the temporal evolution of the organic matter extracted from these trays. To answer this question, the aim of our work was to carry out an initial sensitivity test to determine whether the Rock-Eval® signatures of the samples taken are consistent with past work.

We here found that the standard and advanced parameters obtained in Rock-Eval® thermal analysis were consistent with those obtained in natural litter and in the field. In particular, we clearly identified the decomposition of the most labile materials over the composting time (see Fig. 1) and we matched the signature interval of forest humus in the (I,R) diagram with I ∈ [0.1 ; 0.5] (Sebag et al. 2016).

The conclusions drawn from this initial feasibility study are that it is possible to use this type of worm composter as a model system for studying the impact of earthworms on organic matter thanks to the possibility of isolating the castings over the composting time.

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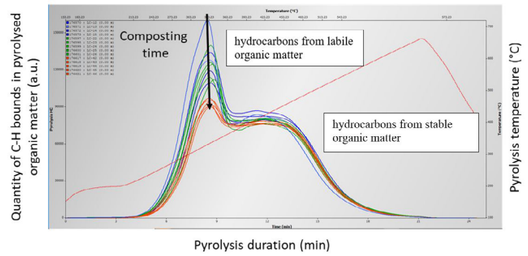


Figure 1: Evolution of the quantity of C-H bounds in pyrolyzed organic matter in casts as a function of composting time.
Sampling was done monthly: blue = sampling month #1; green = sampling month #2; orange = sampling month #3. Reproducibility was obtained based on five replicates. It is shown that hydrocarbon labile compounds significantly decrease on the three months composting duration, while more refractant HC compounds evolve much less on the same period of time.



INDEX

GT 10 - 165 - P

THE CARBON DYNAMICS OF SEASONAL FLOODED SOILS WITH CONTRASTING TEXTURE: THE CASE STUDY OF AN HYGROPHILOUS FOREST IN LIFE GREEN4BLUE PROJECT AREA

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Flooded ecosystems are formed by seasonal or permanent floods and are often characterized by soils exposed to anaerobic processes and conditions. The soils under seasonal flood conditions exhibit discontinuous changes in their properties. The shifting of flood and drought plus the alternation of the erosion and sedimentation processes affect pedogenetic processes and soil properties including organic carbon dynamics. However, such properties are modulated by soil texture since it influences water movement, soil aeration and nutrient availability. The aim of the present research was to assess nutrient and carbon dynamics of loam and clay-loam soils of seasonal flooded hygrophilous forest located within the Life Green4Blue project (LIFE18 NAT/IT/000946) area in northern Italy. The study area has a 70 years old deciduous broad-leaved forest dominated by elm, ash and poplar. Whitin the study area, 2 sites characterized by soil with loam and clay-loam soil texture were identified. In each site, 3 plots 10 m x 10 m wide were selected and one soil profile for each plot was dug. Soil was sampled by pedogenetic horizon and analyzed for the main chemical and biochemical properties. As expected, soil characterized by higher clay content showed higher amount of exchangeable bases, total nitrogen and organic carbon compared with loam soil. Such higher amounts can be attributed to the colloidal features of clay mineral particles which allow the adsorption of nutrients and organic carbon stabilization. Regarding the organic carbon, the higher amount found in clay-loam soil than in loam soil can be also attributed to the higher capacity of the former to store water which can slow the organic matter degradation processes. Indeed, the clay-loam soil showed lower values of 13C than the loam soil suggesting the accumulation of partly decomposed organic matter. From the biochemical view point, clay-loam soil had higher amount of microbial biomass-C than the loam soil which could explain the higher amount of water soluble organic carbon in the former than in the latter since it is recognized that such labile fraction of organic matter is a by-product of microbial community. The higher production of labile organic carbon in clay-loam soil than in loam soil due to microbial activity can be confirmed by the higher values of microbial respiration in the former than in the latter. Despite this, it was interesting to observe a higher metabolic quotient value in clay-enriched soil suggesting a less ideal pedogenetic conditions for the microbial community which, therefore, use organic carbon for catabolic instead for anabolic activity. Overall, the present study highlighted the meaningful influence of soil texture on nutrient and organic carbon dynamics. Specifically, the higher clay content on the one hand promotes the accumulation of nutrients and organic carbon. On the other hand clay-enriched soils of areas subjected to floodings can be unsuitable for the soil microbial community with consequent possible negative influence on nutrient cycles.

ACKNOWLEDGEMENTS

Research co-funded by the Project Life Green4Blue (LIFE18-NAT_IT_000946).

GT 10 - 172 - P

CONTRASTING IMPACTS OF TWO INVASIVE PLANT SPECIES ON SOIL CARBON TRANSFORMATION FUNCTION IN TEMPERATE FORESTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Soil functioning is shaped by plant community composition through processes like litter input, rhizodeposition, and root symbioses. However, invasive plants can alter these processes by introducing litter differing in quantity and quality, affecting resource availability for soil microbes. The plant economic spectrum offers a useful framework for understanding these dynamics, describing a continuum of functional strategies ranging from fast-growing, acquisitive species to slow-growing, conservative ones [1]. These strategies shape soil functioning via litter and belowground inputs. In our study, Prunus serotina represents an acquisitive strategy with labile litter [2], while Rhododendron ponticum exemplifies a conservative strategy with recalcitrant litter [3]. These contrasting models allow us to assess how plant invasions affect soil carbon transformation.

We tested two main hypotheses: (1) Compared to their respective control sites, P. serotina invaded soils are expected to exhibit faster decomposition rates and reduced organic matter accumulation. Conversely, R. ponticum invaded soils should exhibit more recalcitrant litter characteristics, slower decomposition, and increased accumulation of organic matter. (2) The identity of the invading species influences the functional capacity of microbial communities: P. serotina invaded sites would reveal greater functional capacity to degrade labile substrates, while R. ponticum invaded sites would show enhanced capacity to degrade more recalcitrant compounds.

To test these hypotheses, we studied 30 pairs of invaded and non-invaded forest sites, distributed across six forested areas invaded by R. ponticum and three invaded by P. serotina. In each site, four points were sampled. At each point, we recorded soil temperature, moisture, pH, and light availability. Litter samples were collected to assess floristic composition and organic matter inputs. Microbial functional diversity was evaluated through metabolic fingerprints using Biolog Ecoplates. Soil carbon transformation was assessed using several indicators: humus layer thickness, labile carbon content (POXC), basal respiration, and decomposition/stabilization indices derived from the Tea Bag Index (TBI) protocol.

Our results highlight significant functional differences between sites invaded by P. serotina and R. ponticum. The most sensitive indicator was the thickness of the organic horizon, which clearly differentiated the functional impacts of the two species: R. ponticum promotes organic matter accumulation, while P. serotina limits it. At the scale of invaded woods, the woods of P. serotina invaded sites are characterized by high microbial activity and fast degradation rates, whereas R. ponticum invaded sites exhibit lower microbial activity and slower degradation rates.

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GT 10 - 209 - P

TIME TELLS: TRAJECTORIES OF SOIL ORGANIC CARBON AND MICROBIAL PROPERTIES IN THE CZECH AGRICULTURAL LANDSCAPE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Organic C (Corg) is a key factor for many soil functions including nutrient cycling, support of soil biodiversity or formation of soil structure. Appropriate application of this parameter for evaluation of changes of soil organic matter requires a knowledge of its background values and of the natural variability in various agricultural systems. To describe these characteristics, we measured Corg, extractable C (Cext, 0.5 M K2SO4) and microbial properties related to C cycle, namely microbial biomass C (MBC), basal respiration (RES) and substrate-induced respiration (SIR) in arable soils (A, 72 sites) and soils of permanent grasslands (G, 22) in the Czech Republic. Sampling took place repeatedly (6-12 times) between 1999-2005 and 2023. Grassland soils contained more Corg than arable soils (3.03 % and 1.73 %, resp.). A similar ratio G:A was found for Cext (1.73) but higher for MBC (2.31). More organic substrate and MBC resulted in higher RES in grasslands in comparison to arable soils (1.25 and 0.89 CO2-C.g-1.h-1, resp.). Temporal variability expressed as coefficient of variation was within the range 10.9 % and 29.3 % with the lowest values for Corg and the highest for RES. Favourable conditions for microbial growth were expressed by a higher microbial quotient MBC:Corg in grasslands (2.49 %) than in arable soils (1.88 %). Rather lower metabolic quotient qCO2 in arable soils suggests more effective metabolism typical for K-strategists. The ratio G:A for qCO2 was 0.65. Fertilization of arable soils probably lead to conditions supporting opportunistic r-strategist as the higher ratio SIR:MBC in these soils indicated (A:G=1.34). Linear mixed effect models were used to evaluate overall temporal trends in studied soil properties. The concentration of Corg in arable soil was very slightly increasing (0.006 %.y-1) although it remained almost unchanged from the practical point of view. On the contrary, an annual increment was significantly higher in grassland soil (0.02 %.y-1). The most striking effect of management was found in the case of MBC which increased by 12.1 µg.g-1.y-1 in grasslands but this value was approximately 10 times lower in arable soils. This finding is in agreement with an increasing microbial quotient in grasslands (0.024 %.y-1) but no change was found in arable soils. The effect of management on r/K-strategy was pronounced by the ratio SIR:MBC. While the trend was positive for arable soils, it was negative for grasslands (0.39 and -0.78 µg O2.h-1.mgMBC-1.y-1, resp.). Results from additional eight plots on arable land converted into grasslands approximately at the time when sampling began were evaluated to see how the dynamics of studied parameters was sensitive to the change of soil management. Generally, in all cases where differences between both managements was sufficiently high to serve for diagnostic purposes (Corg, Cext, MBC, MBC:Corg and RS:MBC), the temporal trend in soils with changed management was parallel to grasslands.

GT 10 - 245 - P

ENHANCING SOIL ORGANIC CARBON AND SOIL QUALITY THROUGH DOUBLE-CROPPING, CONSERVATION TILLAGE, AND OPTIMIZED NITROGEN MANAGEMENT UNDER MEDITERRANEAN CONDITIONS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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In Mediterranean agroecosystems, conventional agricultural practices have historically led to a marked depletion of soil organic carbon (SOC), compromising soil health and sustainability. This study aimed to assess the combined effects of legume-maize double-cropping (DC), tillage systems, and mineral nitrogen (N) fertilization rates on SOC and its fractions—particulate organic matter carbon (POM-C), mineral-associated organic matter carbon (Min-C), and permanganate-oxidizable carbon (POxC)—as well as on soil enzymatic activities related to the carbon cycle. A field experiment was conducted comparing monocropped maize (MC) with legume-maize DC across two tillage systems (conventional tillage, CT; and no-tillage, NT) and three N fertilization regimes (0, medium, and high). The legumes used included pea for grain (2019), vetch for green manure (2020), and vetch for forage (2021).

Results showed that DC increased SOC compared to MC, primarily through the accumulation of POM-C. DC maintained SOC levels over time, while MC led to a decline relative to initial values. NT significantly enhanced SOC, POM-C, and Min-C in the topsoil (0–10 cm), whereas CT resulted in SOC depletion. Although N fertilization initially increased SOC and its fractions, high N inputs ultimately caused a decline in SOC by the end of the study. Furthermore, DC and NT practices stimulated key soil enzymatic activities, particularly dehydrogenase and β-glucosidase, indicating improved biological functioning.

These findings underscore the potential of legume-maize double-cropping, conservation tillage, and reduced N fertilization as synergistic strategies to preserve SOC and enhance soil biological quality in irrigated Mediterranean cropping systems.



GT 10 - 257 - P

SHORT-TERM INTERCROPPING DOES NOT ENHANCE SOIL AGGREGATE STABILITY NOR ORGANIC CARBON IN A SEMI-ARID MEDITERRANEAN CLIMATE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Enhancing the soil aggregate stability and organic matter quality by increasing organic carbon (C) and nitrogen (N) levels is of great importance to preserve agricultural soils for global food production and mitigate climate change. Intercropping has been claimed a promising strategy due to a greater and diverse input of root residues, root architecture, etc. [1]. This study aimed to assess the effect of intercropping on soil aggregation and C/N storage in aggregates under semi-arid Mediterranean conditions [3].

A three-year irrigated on-farm field experiment under vertical tillage was established in 2020 in NE Spain to evaluate the effect of seven cropping systems (faba bean (Vicia faba L.)-durum wheat (Triticum durum Desf.), pea (Pisum sativum L.)-durum wheat, rapeseed (Brassica napus L.)-pea and the respective sole crops). The second factor was mineral N-fertiliser (0 and 75 kg UAN-N ha-1, 0N and 75N, respectively). Mean air temperature and annual precipitation were 14.0°C and 369 mm, respectively. The soil was a Typic Calcixerept with a clayey texture (USDA) and a pH of 8.3. A randomised complete block design with three replications was used. At the flowering stage in 2023, topsoil (0-5 cm) and subsoil (5-30 cm) were sampled and water-stable macro- and microaggregates (>250 µm and 50-250 µm, respectively) were fractionated manually (only topsoil). Both aggregate fractions and bulk soil were analysed for soil organic carbon (SOC), several C-fractions and soil total nitrogen (STN). Furthermore, microbial C (MBC) and N (MBN) were determined in bulk topsoil.

Intercropping had no significant effect on the share of water-stable aggregates. Only rapeseed (42.9 g 100 g-1) showed higher values than wheat (34.9 g 100 g-1) and faba bean (34.3 g 100 g-1) sole crops (Fig. 1). There was also no effect of cropping system on SOC, but SOC was higher in macro- than in microaggregates (2.34 vs 1.89 g 100 g-1). Intercropping also did not affect STN. Differently, both SOC (2.24 vs 2.08 g 100 g-1) and STN (0.193 vs 0.177 g 100 g-1) were higher in 75N compared to 0N in bulk soil. MBN was higher in 75N (105 µg N g-1) than in 0N (90.9 µg N g-1), while MBC remained unaffected. This study showed that intercropping did not enhance soil aggregate stability nor soil C or N levels. This work has been funded through the projects Biodiversify (aid PCI2020–112297 by MCIN/AEI/10.13039/501100011033) and LegITIMada (2023 CLIMA 00018) through the Generalitat de Catalunya.

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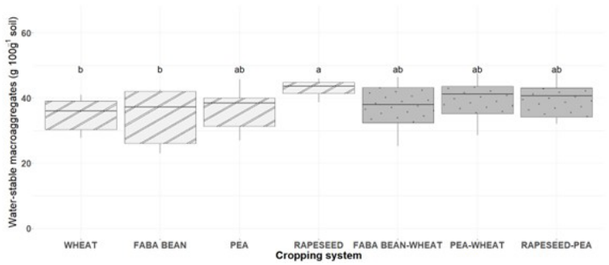


Fig. 1 Distribution of water-stable macroaggregates under sole crops (light grey) and intercropping (dark grey).

GT 10 - 284 - P

USING REGRESSION-BASED MODELS TO ESTIMATE SOIL ORGANIC CARBON SATURATION CAPACITY AND SEQUESTRATION POTENTIAL IN TAIWAN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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As global attention increasingly turns to Soil Organic Carbon (SOC) sequestration as a climate change mitigation strategy, this study estimates Taiwan's SOC sequestration potential (SOCsp) at a national scale. Fine fraction soils (<53 µm) are known to stabilize SOC over the long term and are assumed to have an upper accumulation limit—referred to as the SOC saturation capacity (SOCsat). The difference between SOCsat and the current SOC content in the fine fraction soil is used as an indicator to assess the topsoil (0–30 cm) SOCsp. Using a high-density soil sampling dataset (>1 sample km^{-2} in cultivated areas), we developed localized SOCsat estimation equations based on three regression approaches: Hassink (1997), boundary line (BL), and quantile regression (QR). Using digital soil mapping (DSM) combined with environmental covariates, and employing a random forest model for spatial prediction, a national-scale 90-meter resolution SOCsp map was created. Results show that the BL method produced a higher slope (0.41) compared to the QR method (0.27), resulting in SOCsp stock estimates from the BL and Hassink methods (107–119 Mt) being approximately twice as high as that from the QR method (51 Mt). This highlights that SOCsat estimation is sensitive to sample composition, data characteristics, regression methods, and underlying assumptions. Random forest model validation showed good predictive performance (R^2: 0.54–0.57). Variable importance analysis revealed that soil type, temperature, and precipitation were the most important environmental covariates driving the spatial distribution of topsoil SOCsp. Finally, the prediction interval results revealed greater uncertainty not only in mountainous areas with lower sampling density but also in southwestern Taiwan, where both predicted SOCsp and sampling density are higher. This study generated the first national-scale SOCsp map of Taiwan, which can serve as a valuable reference for policymakers in setting goals and strategies to enhance soil organic carbon sequestration in Taiwan.

ACKNOWLEDGEMENTS

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GT 10 - 306 - P

ECTOMYCORRHIZAL FUNGI AND FOREST CARBON SEQUESTRATION IN TAIWAN: COMMUNITY COMPOSITION AND FUNCTIONAL IMPLICATIONS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Ectomycorrhizal (ECM) fungi are integral to forest ecosystems, influencing nutrient cycling and carbon sequestration. This study investigates the diversity and functional roles of ECM fungal communities across various forest types in Taiwan, aiming to elucidate their contributions to soil carbon dynamics. We conducted comprehensive field surveys and soil sampling in multiple forest sites, employing high-throughput sequencing to characterize ECM fungal communities. Our analyses revealed a dominance of ECM taxa such as Russula, Tomentella, and Cenococcum species, with notable variations in community composition correlating with forest type and environmental gradients. Functional profiling indicated that certain ECM taxa possess enzymatic capabilities for decomposing complex organic matter, potentially enhancing soil carbon storage under nitrogen-limiting conditions. Comparative analysis with global studies indicates that the ECM fungal communities in Taiwan's forests exhibit unique compositional and functional traits. For instance, the prevalence of Cenococcum geophilum, known for its melanized hyphae and resistance to decomposition, suggests a potential for long-term carbon sequestration in these ecosystems. This aligns with findings from other regions where C. geophilum contributes significantly to soil carbon pools due to its recalcitrant biomass. Furthermore, our study highlights the sensitivity of ECM fungal communities to climatic factors. Experimental warming and altered precipitation patterns have been shown to shift ECM community composition, potentially affecting their functional roles in carbon cycling. Understanding these dynamics is crucial, as ECM fungi not only facilitate nutrient uptake for host trees but also modulate soil carbon storage through their interactions with organic matter and other soil microorganisms. In conclusion, the ECM fungal communities in Taiwan's forests play a pivotal role in carbon sequestration, with their composition and function influenced by both biotic and abiotic factors. These findings underscore the importance of incorporating microbial community dynamics into forest management and climate change mitigation strategies.

ACKNOWLEDGEMENTS

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GT 10 - 337 - P

TEMPERATURE SENSITIVITY OF BIOCHAR-AMENDED SOIL AT LOW TEMPERATURES AND THE ROLE OF CARBONATES IN ESTIMATING BIOCHAR PERSISTENCE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Understanding how soil respiration responds to temperature is critical for predicting climate carbon (C) feedback. Biochar has been proposed as a climate mitigation strategy due to its C sequestration potential, yet its effects on the temperature sensitivity (Q_{10}) of soil respiration remain unclear under low temperatures representative of the Nordic climates. Additionally, biochar incorporation can trigger an initial CO_2 pulse driven by abiotic processes. This study investigated the impacts of two contrasting commercial biochars on Q_{10} values and the contribution of carbonate-derived CO_2 to the estimates of biochar C persistence over a 575-day incubation at 5, 11, 16, and 21 °C. We found that Q_{10} values were highest at the lowest temperature interval (5–11 °C). Biochar had no effect on Q_{10} at this range but potentially reduced Q_{10} at higher temperatures. Our conservative estimates showed that biochar addition increased the mean residence time of C in soil from 13-41 years to 27-102 years as estimated by a simple first-order model. Also, using PLFA analysis, we found that biochar had limited impact on the microbial community, except for an increase in arbuscular mycorrhizal fungi. These results point at the potential of biochar to sequester C in soils in the context of climate change. Notably, we found that carbonate-derived CO_2 contributed significantly to early respiration peaks and failing to account for this abiotic flux may lead to an underestimation of biochar stability in soils. Overall, these findings support the potential of biochar for climate mitigation and the need to consider abiotic pathways when assessing biochar persistence in soils.



GT 10 - 364 - P

SOIL CARBON QUANTITIES IN ORGANIC SOILS AT VARIOUS MANAGEMENT STRATEGIES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The study comprised the determination of carbon and nitrogen contents in five peatlands with varying management strategies: drained peatland used as arable land, drained peatland used as a 4-cut meadow, drained peatland used as a 2-cut meadow with drainage and rewetting periods, drained peatland being a fallow, and a rewetted peatland. The C and N contents were measured on a VarioMaxCube CN Elementar analyser.

The greatest variability of C and N values was observed in the peatland being a fallow. It had a significantly lower C/N ratio (average 9.3), which indicated rapid decomposition of organic matter and potential degradation. The peatland managed as a 2-cut meadow, but with episodes of being drained or rewetted had uniform C and N contents (approx. 30% C) and quite uniform C/N ratio, amounting to ~12. This C/N ratio indicated good conditions for organic matter mineralisation, which in the case of peatlands is associated with secondary humification of organic matter and indicates process of degradation. The subsurface horizons of this peatland had high C/N ratios (>27) indicating occurrence of untransformed organic matter.

The rewetted peatland had diversified contents of C and N, and the C/N ratio ranged from 5 to 16. The presence of organic material with a wide C/N ratio (>14) indicates the accumulation of undecomposed biomass or newly formed peat.

In turn, the contents of C in the peatland used more intensively – part of it as arable land and part as a 4-cut meadow, were high (C > 30%). At arable land high contents of C (average 35.9%) were accompanied by a relatively high nitrogen level (3.0%). The C/N ratio was on average 11.6, which indicates the presence of well-humified organic matter. At a 4-cut meadow average C content was higher (36.99%) and N content lower (2.9%), which resulted in wider C/N ratio of 12.3, indicating that slower rate of nitrogen mineralization occurred in the 4-cut meadow than in the arable land. Nevertheless, it should be noted that both parts of this peatland were in a good state of preservation (C/N ratio >10).

GT 10 - 368 - P

INTERPLAY OF PLANT BIODIVERSITY AND SOIL ORGANIC MATTER DYNAMICS: INSIGHTS FROM ENVIRONMENTAL AND MEADOW MANAGEMENT GRADIENTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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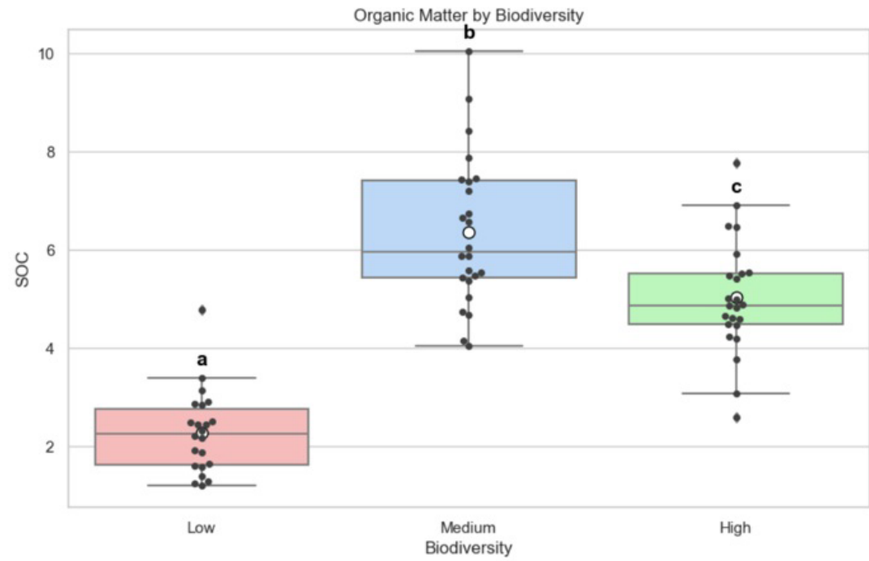
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In this study, we investigated the interrelations between biodiversity and organic matter dynamics across 15 meadows located in the Spanish Central Pyrenees. Employing Braun-Blanquet vegetation inventories, we calculated the Shannon Index to characterize each meadow's plant diversity. Based on these index values, sites were stratified into three biodiversity levels: low (Shannon <2,36), medium (Shannon 2,36-3,14), and high (Shannon >3,14), to elucidate the relationship between meadow biodiversity and soil organic matter.

A comprehensive suite of parameters was measured, including altitude, livestock load, nitrogen fertilization (discriminated between mineral and organic sources), and vegetation composition (percentage cover of grasses, legumes, and other plant families). In addition, the evolution of soil organic matter was tracked from February through June to assess seasonal fluctuations in soil quality.

The results show that the highest organic matter contents are found in meadows with medium diversity, while the lowest values are found in the least diverse meadows (Fig 1). These less diverse meadows have lower altitude, higher % of grasses and higher stocking rates. The high organic matter contents of intermediate diversity grasslands seem to be more directly related to organic nitrogen fertilization than to any of the environmental or vegetation parameters analysed.

The seasonal assessment of soil organic matter further underpinned the influence of biodiversity on soil processes. Medium biodiversity sites experienced a notable decline in organic matter from February to June, whereas high biodiversity areas showed a subtle increase. Low biodiversity meadows, by contrast, maintained relatively stable organic matter levels over the same period. These dynamics suggest that biodiversity level and associated management practices are intrinsically linked to both vegetation structure and soil organic matter trajectories, thereby influencing the ecological sustainability and functionality of montane meadow systems.



GT 10 - 455 - P

SPATIAL VARIABILITY OF SOIL ORGANIC CARBON IN PINUS RADIATA PLANTATIONS LIMITS THE DETECTION OF CHANGE OVER TIME

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Accurate estimation of soil organic carbon (SOC) stocks requires reliable measurement of SOC concentration, bulk density, and coarse fragment content. While all three variables are influenced by spatial heterogeneity, this study focuses on the challenge of obtaining representative SOC concentration data, crucial for high-integrity carbon accounting. Large-scale monitoring, especially for carbon farming and climate policy frameworks, is often constrained by the high cost and labor intensity of fieldwork and laboratory analysis.

To address these limitations, Area-Frame Randomized Soil Sampling (AFRSS) has been proposed as a scientifically robust, transparent, and cost-effective method. AFRSS uses a spatially stratified random sampling design over a fixed area-frame grid to ensure statistical representativeness across heterogeneous landscapes.

We applied AFRSS methodology in three adjacent Pinus radiata plots with similar soils (Distric Cambisol) but different age and management history: post-harvest stage (clearcut and replanted in 2008), mid-rotation stage (20 ys in 2010 and undisturbed from 2010 to 2024), and mature stage (mature in 2010, harvested and replanted in 2012). A randomized sampling grid template was adapted to each plot, and three cells per plot were selected as AFRSS sites. All other grid cells within the plot boundaries were also sampled (referred to as "all sampling sites"). In each sampling site, a total of 25 subsamples (0–10 cm depth) were composite into a single sample and analyzed for SOC concentration using an elemental analyzer. Total carbon was equated with SOC due to absence of carbonates. Changes in SOC concentration (ΔSOCc, g C kg^{-1} $year^{-1}$) were calculated as the difference between 2024 and 2010 SOC concentrations. Wilcoxon tests were used to compare overtime differences in SOC concentration between AFRSS sites and all sites within each plot.

AFRSS median and interquartile range ΔSOCc values were: 0.12 ± 1.11 (post-harvest), 0.84 ± 0.60 (mid-rotation), and 0.13 ± 1.48 (mature) g C kg^{-1} $year^{-1}$. For all sampling sites: 0.03 ± 1.22, 0.36 ± 0.74, and 0.04 ± 1.40 g C kg^{-1} $year^{-1}$, respectively. No statistically significant overtime differences were found between AFRSS and full-grid estimates, and no significant change in SOC concentration was detected in any of the plots over the 14-year period. These results highlight the challenge of detecting SOC change in planted forests due to high spatial variability, even over decadal timescales and despite extensive spatial sampling efforts. To improve detection sensitivity, reducing within-plot variability through stratified sampling or applying model-based approaches (e.g., mixed-effects or geostatistical models) may help account for spatial structure and isolate real temporal changes.

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GT 10 - 474 - P

ESTIMATION OF CO2 ADSORPTION ON WOOD ASH BY 1 M AMMONIUM ACETATE EXTRACTION

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Power generation from woody biomass has been attracting attention from the viewpoint of resource depletion. A 0.5-12 wt. % of wood ash is generated during the power generation. Wood ash is reused at various uses, such as fertilizer and CO2 adsorption material. Vassilev et al. [1] reported that mineral carbonation leads to strong crystallization of carbonate and bicarbonate in the wood ash, resulting in the CO2 fixation. However, the amount of CO2 adsorption of wood ash and CO2 phases adsorbed depends on the composition of the raw materials used for power generation during combustion. In particular, the contribution of CO2 adsorption by carbonate formation to the total amount of CO2 adsorbed and the estimation of the amount of CO2 adsorbed onto each wood ash are still unknown. Calcium carbonate is insoluble in solutions with pH greater than natural, and thus, we hypothesized that the decrease in the amounts of ammonium acetate soluble (AAS) calcium at pH 7 before and after CO2 adsorption results from calcium carbonate formation with CO2 adsorption. This study aimed to clarify the quantitative relationship between the amount of CO2 adsorbed by wood ash and CO2 adsorbed by calcium carbonate formation, as well as to determine whether the amount of CO2 adsorption can be predicted in advance based on the chemical properties of the wood ashes.

Nine types of wood ash from different power plants were tested, and the maximum CO2 adsorption capacity of each ash was determined by CO2 adsorption tests. Other two different CO2 adsorption levels of wood ash was also prepared for each ash in the process of reaching the maximum adsorption capacity. The amount of calcium extracted from the ashes before and after CO2 adsorption was analyzed by 1 M ammonium acetate (pH 7).

The maximum amounts of CO2 adsorbed by wood ash ranged from 0.18 to 1.86 mmol/g, depending on the ash type. The amount of AAS calcium was the highest before adsorption, but their amounts decreased with the increase in the amounts of CO2 adsorption. The amounts of AAS calcium were similar regardless of the ash type after the maximum amount of CO2 adsorption was reached. A positive linear relationship was observed between the amount of AAS calcium before CO2 adsorption and the total amount of CO2 adsorbed by the wood ash. Further, the amount of CO2 adsorbed by calcium carbonate formation corresponded to 57~101% of the total amount of CO2 adsorbed by the wood ash. Therefore, this study suggests that the measurement of the amount of AAS calcium in wood ash would be applied to determine whether or not the wood ash is possible to adsorb a large amount of CO2.

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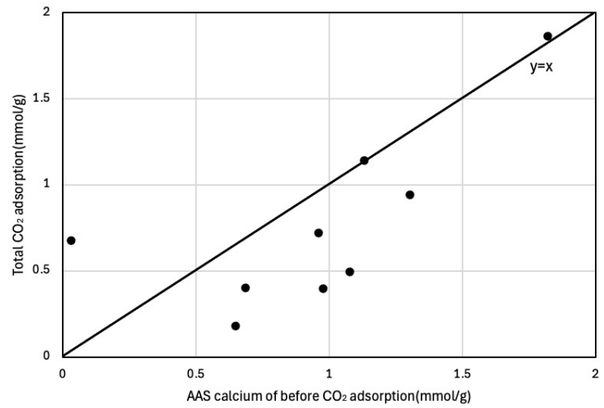


Fig.1 Relationship between amount of AAS calcium of before CO2 adsorption and total amount of CO2 adsorbed by wood ash



GT 10 - 480 - P

SOIL CARBON DYNAMICS ACROSS SEASONS: INSIGHTS FROM CONTRASTING LAND MANAGEMENT PRACTICES IN SPAIN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Soil is the second-largest active carbon reservoir, storing 1,500–2,400 Gt globally, making it critical for climate change mitigation (Lal, 2004; European Union, 2011). Soil carbon stocks are shaped by physicochemical properties, climate, and land use, therefore effective management is key to enhancing carbon sequestration (Paustian et al., 2016; Beillouin et al., 2022). This study examines the impact of seven land management practices on soil carbon and health.

Three samples from each management were taken in semi-arid central Spain under conventional tillage, no-tillage, direct seeding, livestock integration, and unmanaged systems. Each site was characterized for organic matter content (OM%), total organic carbon (TOC), microbial diversity and biomass, and fungal-to-bacterial (F:B) ratios. A composite Carbon Stability Score (CSS) was developed, combining carbon persistence (80%), microbial ratios (15%), and C:N ratios (5%). Greenhouse gas fluxes (CO_2, CH_4) were also measured to compare emissions across practices.

Preliminary results from the March 2025 sampling highlight strong effects of land management on carbon levels and stability. No-tillage and tree-integrated systems had the highest OM%, TOC, and CSS. Tillage substantially reduced microbial biomass and carbon retention, aligning with Beillouin et al. (2022) and Lehmann & Kleber (2015). Soils with more diverse microbial communities and balanced F:B ratios showed greater carbon stabilization. These results reinforce links between microbial ecology and long-term carbon storage (Paustian et al., 2016).

GHG data reveal that emissions are not always inversely related to carbon stocks. Emission patterns appear more influenced by microbial metabolism and moisture regimes than carbon content alone. Conventional tillage emitted nearly three times more CO_2 than all other systems. In contrast, light tillage and animal integration produced lower emissions than an unmanaged plot left undisturbed for 30 years.

To assess seasonal effects, a second sampling in June 2025 will compare early spring and summer soil conditions. This will enhance our understanding of temporal dynamics in carbon cycling and support targeted, climate-smart soil management strategies suited to Mediterranean agroecosystems.

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The authors want to thank the family Charro Moro for letting us sample their land and helping us select the sites

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GT 10 - 506 - P

INFLUENCE OF MANAGEMENT IN THE DEHESA OF THE PEDROCHES VALLEY ON CARBON SEQUESTRATION IN SOIL AGGREGATES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Dehesas are typically Mediterranean agroforestry systems that integrate agricultural, livestock and forestry practices in a sustainable manner. These ecosystems play a relevant role as carbon sinks, mainly through soil storage, plant biomass and organic residues. The work presented analyzes the influence of management on carbon sequestration and its distribution in the different soil aggregate fractions, taking as a case study a farm in the Pedroches Valley (Córdoba).

The study focuses on how management practices such as rotational grazing, manure fertilization and crop rotation affect the soil's capacity to store soil organic carbon (SOC). Four plots in different states of crop rotation were compared, including one with no intervention as a control. In each plot, samples were taken at two depths (0-10 cm and 10-30 cm), under oak canopy and in bare areas.

Variables such as soil aggregate size distribution, weighted mean diameter (MWD) and geometric mean diameter (GMD), and organic carbon content and stock were measured. The results revealed that the areas under canopy show greater structural stability and carbon accumulation, especially in macroaggregates. Likewise, the most recently managed plot (sodded and seeded) showed the highest values of SOC stock, evidencing the immediate impact of management.

It was also observed that SOC stocks decrease with time since the last agricultural intervention, suggesting that much of the accumulated carbon corresponds to labile fractions. Appropriate practices increase the stability of aggregates and, therefore, of soil carbon, while inadequate management or lack of management leads to a decrease in sequestration capacity.

Finally, the paper concludes that a planned and regenerative management of the dehesa, with practices such as rotational grazing, controlled sowing and organic fertilization, significantly improves the capacity of the soil to act as a carbon sink, thus contributing to the mitigation of climate change and the maintenance of ecosystem health.



GT 10 - 614 - P

IMPACT OF LONG-TERM TILLAGE PRACTICES ON SOIL CARBON SEQUESTRATION AND ORGANIC MATTER FRACTIONS IN A CHERNOZEM SOIL

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Intensive agricultural practices contributed to global environmental problems: increasing greenhouse gas (GHG) emissions, global warming and resulted in soil degradation processes: decline in soil organic matter content (SOM), compaction, loss of biodiversity, erosion etc. Desirable agricultural and tillage practices and strategies can increase soil organic carbon (SOC) and nitrogen (N) stocks, enhancing soil ecological functions, while also contributing to climate change mitigation. Sustainable soil management practices support the accumulation of the two main SOM fractions, particulate organic matter (POM) and mineral-associated organic matter (MAOM). The objective of this study was to evaluate the effects of different long-term soil tillage practices on soil carbon (C), nitrogen (N) content and SOM fractions in a long-term tillage experiment.

The long-term tillage experiment is located at the Józsefmajor Experimental and Training Farm of the Hungarian University of Agricultural and Life Sciences, Hungary. The long-term experiment was established in 2002, with six different soil tillage practices: disking, shallow tine cultivation, no-till, deep tine cultivation, loosening, conventional mouldboard ploughing. The representative soil refences group of the experiment is Endocalcic Chernozem (Loamic). The experiment design was arranged in a randomized block arrangement with four replicates, and the area of each plot is 2340m2 (13m×180 m). In the present study, three tillage treatments were selected: conventional ploughing (P), shallow cultivation (SC), and no-till (NT).

Soil samples were collected at five depth intervals: 0-10 cm, 10-20 cm, 20-30 cm, 30-50 cm, 50-70 cm right after winter wheat harvesting on 10th of July in 2024.

The study included total carbon and nitrogen (CN) measurements (Dumas method, VarioMAX Cube elementar analyser, Elementar GmBH, DE), for each sampled horizon, and the calculation of CN stocks for each depth interval as well as for combined depths (0–30 cm, 0-50 cm, and 0–70 cm). The mass and CN content of POM and MAOM fractions were determined too. Derived aggregate stability index was also calculated based on the distribution and carbon content of the POM and MAOM fractions.

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GT 10 - 632 - P

ROOT PHENOTYPING FOR SOIL CARBON STORAGE IN PERENNIALS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Increasing soil carbon (C) storage through perennial crop roots is a promising tool for mitigating climate change and maintaining soil fertility. Current methods for comparing the roots of different species and genotypes for their potential to contribute to soil C are laborious and not suitable for plant (pre)breeding.

Here, we evaluate a root phenotyping method that involves a single pulse of $^{13}CO_2$ applied at peak root growth, followed by measurement of the tracer in mixed soil–root samples at the time point when its concentration is highest. Additionally, we explore the potential to further simplify the method by fractionating the labeled C pool into thermal stability groups using a modified Rock-Eval analysis coupled with real-time ^{13}C measurement.

In the second year of crop establishment, we tested this method using a set of contrasting perennial species—two forbs (chicory and plantain) and two grasses (tall fescue and perennial ryegrass)—chosen for their differing rooting patterns. A single $^{13}CO_2$ pulse was applied in May, and soil was sampled to a depth of 100 cm at 2, 5, and 8 days post-pulse to identify the time point with maximum belowground ^{13}C allocation. The highest tracer levels were detected 5 days post-pulse. At this time, plantain allocated more ^{13}C to the 0–25 cm soil layer than chicory, despite chicory having higher root biomass at that depth, suggesting more active root growth or C allocation by plantain in the upper soil layer. In the third year, we applied the same method—using a single $^{13}CO_2$ pulse at peak root growth— and sampled 5 days post-pulse. We included five perennial ryegrass genotypes to assess within-species variation, along with plantain, tall fescue, and festulolium [results pending].

Additionally, we are currently coupling a Rock-Eval 6 instrument with a Picarro isotopic analyzer. Once calibration is complete, we will analyze the soil samples with the aim of deconvoluting the $\delta^{13}C$ thermograms to distinguish between different ^{13}C-labelled organic carbon pools [results pending].

In summary, this method shows preliminary promise for comparing the potential of perennial root systems to contribute to soil carbon storage, enabling relatively fast evaluation of belowground carbon inputs and detecting differences between species.



GT 10 - 672 - P

ASSESSMENT OF SOIL CARBON STORAGE CAPACITY AND CONDITION IN TAIWAN

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soil is the largest terrestrial organic carbon reservoir and plays a critical role in mitigating climate change and promoting carbon sequestration. However, the potential for soil carbon storage is constrained by interactions between minerals and organic carbon and is strongly influenced by land use and management practices. This study, based on the Soil Security Framework, uses mineral-associated organic carbon (MAOC) as an indicator to assess soil carbon storage capacity (the maximum functional performance determined by inherent properties and less influenced by human activities) and soil carbon storage condition (the current state of the soil influenced by management and external factors) under different agricultural land uses in Taiwan. The MAOCmax(representing carbon storage capacity), estimated using boundary line regression models and fine fraction soils (less than 53 μm), averaged 8.81, 8.46, 7.23, and 6.07 kg m^{-2} across paddy fields, dry croplands, orchards, and forest, respectively. The corresponding average MAOC saturation levels (representing carbon storage condition), calculated from observed values, were 17.54% for paddy fields, 16.01% for dry croplands, 14.76% for orchards, and 22.36% for forest. Further analysis of the trends in soil organic carbon from 2000 to 2020 showed a negative correlation between the rate of MAOC accumulation and the initial MAOC saturation level (in 2000), indicating that soils with lower carbon saturation have a higher potential for carbon sequestration. Among the different land cover types, paddy soils exhibited the strongest correlation between MAOC accumulation rate and saturation level (R^2 = 0.489). Overall, understanding MAOC saturation status and its spatial distribution cross different land use types can support the identification of priority areas for soil carbon sequestration and the development of effective soil management strategies.

GT 10 - 673 - P

INTEGRATING SOIL ORGANIC CARBON STOCKS AND NET ECOSYSTEM PRODUCTIVITY – A DSM APPROACH TOWARDS THE EVALUATION OF SOIL CARBON SEQUESTRATION

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soils are one of the ecosystem elements with a high potential in climate change mitigation by sequestering CO_2. At the same time, soils, especially rich in soil organic carbon (SOC) are susceptible to the emissions of greenhouse gasses, including CO_2, to the atmosphere. In this group of soils, we can include agricultural land, and degrading organic soils. Both are potential high emitters of GHG. Quantifying carbon sequestration potential of soils requires an integrative approach that considers both static soil organic carbon stocks (e.g., SOC stock) and dynamic indicator of carbon fluxes, such as Net Ecosystem Productivity (NEP). In this study, our aim is to provide spatially explicit assessment of soil carbon sequestration potential across agricultural land in Poland by combining high-resolution maps of SOC stock and NEP. We believe that this integrating approach will significantly contribute to the upcoming challenges of soil protection, especially those resulting from EU directives.

For this reason, we modelled SOC stocks using DSM approach and QRF algorithms (Quantile Regression Forest). We used a set of 73 harmonized environmental covariates, including land use, vegetation, topography, and soil properties. To calculate SOC stocks we modelled three maps: SOC content (approx. 40000 points), bulk density (approx. 16000 points), and fraction > 2mm (approx. 16000 points). In the modelling process we used Boruta algorithm and 15-fold cross-validation in 10 repetitions. To calculate NEP, we used ORNL DAAC NASA data on soil respiration, solar radiation from WorldClim data, NDVI calculated from Sentinel-2, and Fraction of Absorbed Photosynthetically Active Radiation for 2018 from Copernicus data. To indicate the areas of the highest potential for SOC sequestration we normalized both indicators and used geometric mean to calculate the final rank of the sequestration. The highest rank, the biggest potential to provide this ecosystem service.

As a result, we found out that for all the analysed areas, the emissions dominate over sequestration (negative NEP), however, many soils in Poland have relatively big SOC stocks. Interesting is that the biggest potential CO_2 emissions characterise soils with the highest SOC stocks. These areas were located in the southern part of Poland and the northeast, where the carbon-rich soils occur. This means that in the light of the EU directives on soil protection and conservation, these soils should be under a special protective management (intercrops, conservation tillage or no-till farming, crop rotation, mulching, etc.). This is why our results are a strategic importance for implementing sustainable soil management practices and soil protection. We proved that the dual-indicator evaluation provides better insight for the evaluation of the carbon fluxes in the agricultural soils.



GT 10 - 695 - P

A WEB APPLICATION FOR DOCUMENTING MANAGEMENT PRACTICES TO INCREASE SOIL CARBON STOCKS AND ENHANCE SOIL QUALITY IN AGRICULTURE, FORESTRY, AND URBAN GREEN SPACES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Although soil organic matter represents only a few percent of the total soil mass, it plays a major role in the physical, chemical, and biological functioning of soils. It promotes the formation of stable aggregates and thus contributes to soil structural stability, particularly through its association with clay minerals. The resulting porosity supports good root penetration, water infiltration and retention, and air circulation. This leads to improved resistance to compaction and erosion, efficient drainage, and the availability of water for plant development.

Today, global change challenges, CO2 emission reduction goals, and the potential of soils to store or sequester carbon have brought this area of research to the forefront.

In Europe, both land use patterns and the management practices of socio-ecological systems significantly influence Soil Organic Carbon (SOC) levels. In this context, advisory bodies in the agricultural sector often lack decision-support tools to guide land managers in maintaining—or ideally increasing—SOC levels.

We are currently developing an application aimed at supporting stakeholders in the agricultural, forestry, and urban green space sectors (parks and gardens) in Wallonia (Belgium). The tool focuses on the links between management practices and soil quality, with particular emphasis on SOC content. The application consists of two components: (i) an inventory of innovative and (agro)ecological practices, and (ii) a SOC modelling tool. It will be freely accessible to land managers, advisory services, policymakers, researchers, and all interested citizens.

The inventory component, based on research conducted at European, national, and regional levels, compiles a list of 147 practices that contribute to improved soil quality and health, particularly through enhanced soil carbon levels.

The modelling component focuses on agricultural systems. We are integrating a version of the Roth-C model, adapted by INRAe as part of the European Carboseq project (EJP SOIL). This model allows the simulation of the impacts of adopting new practices—such as crop rotation changes, cover crop integration, organic matter amendments, and irrigation—on SOC dynamics over a 20-year horizon.

The outcomes of this approach are relevant to a range of stakeholders, including policymakers, researchers, and advisory services involved in the management of agricultural, forestry, and urban socio-ecological systems.

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Inventory of soil management practices in agriculture, forest and green spaces.

GT 10 - 714 - P

ANALYTICAL UNCERTAINTY IN SOC AND SIC DETERMINATION: IMPLICATIONS FOR CARBON CERTIFICATION FRAMEWORKS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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In the context of increasing regulation of soil management strategies affecting carbon storage—e.g. EU Regulation 2024/3012 establishing a certification framework for permanent carbon removals, including carbon farming—the accurate quantification of soil carbon stocks becomes a scientific and socioeconomic priority.

The net impact of agronomic and forestry practices on soil organic carbon (SOC) is site-dependent [1], partly due to soil variability. Their effects on soil inorganic carbon (SIC), mostly as carbonates, are less well understood, although evidence shows management can alter SIC stocks, including losses via acidification [2]. Detecting changes in SOC and SIC faces challenges related to sampling, bulk density, and analysis. These issues are more critical in calcareous soils, where SOC and SIC may interfere with each other's determination.

This study tested the uncertainty induced by different analytical methods for SOC and SIC determination at a regional scale. We analyzed 210 soil samples from the Basque Country and Navarre (Spain) using standardized approaches in two labs. At UPNA, SOC was measured using the Walkley-Black method and SIC with an adapted Bernard (Sherrod) calcimeter. At NEIKER, both SOC and SIC were determined with an elemental analyzer (Soli TOC Cube, Elementar).

Samples spanned a wide carbon range: SOC from <2 to >130 g C kg^{-1} soil and SIC from 0 to >50 g C kg^{-1}. Based on FAO's World Reference Base, 100 samples were highly calcareous and 75 carbonate-free. Linear regression models compared results between labs. Across the full sample set, SOC values differed by up to 23% (R^2 = 0.89). For samples below 50 g C kg^{-1} (a threshold proposed for SOC saturation; [3]), the difference dropped to 13% with a better fit (R^2 = 0.91).

We hypothesized that carbonates interfere with SOC determination. Separate regressions for highly calcareous and carbonate-free samples showed SOC differences of 9% and 21%, respectively. For SIC, the regression indicated a 65% difference between methods (R^2 = 0.95).

These findings show that method choice can cause variation in carbon estimates comparable to the effects of many carbon farming practices. This highlights the need for harmonized methods and inter-lab calibration in monitoring, reporting, and verification (MRV) frameworks.

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GT 10 - 742 - P

COMPARISON OF CARBON STOCK AND NUTRIENT CONTENT IN THE SOILS IN CLOSE-TO-NATURE AND MANAGED FORESTS IN THE CZECH REPUBLIC.

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Forest soils contain nearly half of the global stock of soil organic carbon (Corg). The proportion of more mobile stock in the upper organic layer and more stable stock in the mineral horizons of soils varies depending on soil properties, climate, vegetation cover and type of management. Since carbon storage in natural ecosystems is one of the important measures to mitigate the climate change, it is important to define management practices to increase carbon stocks in soils. In the case of forestry, there is a particular interest in the question of whether a forest ecosystem with limited human influence can store significantly more carbon, especially in its soils, or whether an intensive forest management is more favourable for the overall carbon balance. This issue is also closely related to the sustainability of nutrients, which can be depleted by a combination of acid deposition and intensive management, especially on nutrient-poor bedrocks.

To enlighten the question we have compared soil properties in 10 pairs of managed and nature-protected forests growing in close proximity. The samples of upper organic layer (FH) upper mineral soil (layers 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm) and subsoil (layers 40-80 cm and 80-100 cm) were taken from the soil pit and from 5 drilled points per plot. The following chemical analyses included soil acidity, Corg, Ntot, Stot, ectractable (Aqua regia extraction) and exchangeable (BaCl2 extraction) elements. Moreover 20 extra samples of upper organic layer and upper mineral soil per plot were taken and analysed to better cover the variability in soil acidity, Corg and Ntot.

The results suggest that there is no difference in carbon stock related to forest management – the variability in Corg stock was driven by the stoniness and the bulk density of the soil at individual localities. On the other hand, we found different patterns in the distribution of basic cation content and base saturation in pairs of plots where the original tree composition (usually deciduous or mixed tree species) was converted to Norway spruce stands. There was significantly lower base saturation and lower concentration of Ca and Mg in the upper mineral soil under the artificially planted Norway spruce monoculture comparing to close-to-nature forests. In subsoil, however, the situation was similar or even more favourable in managed stands.

ACKNOWLEDGEMENTS

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GT 10 - 816 - P

SOIL ORGANIC CARBON STORAGE IN CITRUS AND AVOCADO ORCHARDS.

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Food production has traditionally been linked to the emission of greenhouse gases, particularly carbon dioxide (CO_2). However, agriculture, especially permanent crops and the practices they involve, can also play a significant role in mitigating climate change. Today's agricultural practices increasingly focus on preventing soil erosion and improving soil fertility. Fruit growers now often sow cover crops between orchard rows or allow spontaneous vegetation to grow. This vegetation is later mechanically shredded, contributing to the increase of soil organic matter. In planting rows, however, the use of herbicides remains common in some crops, such as citrus. A notable exception is avocado cultivation, as avocado trees naturally create a dense layer of mulch from their fallen, dry leaves. This organic layer suppresses weed growth, eliminates the need for herbicides within the rows, improves soil fertility and enhances water retention. As avocado trees mature, this leaf mulch gradually extends to cover the entire orchard surface, including the inter-row areas, further minimizing the need for weed control. Over time, as permanent crops reach a certain stage of maturity and are managed using more regenerative practices, these systems can become effective carbon sinks.

To assess the contribution of permanent crops to organic carbon storage, citrus and avocado orchards are being monitored. The two plots are in proximity, allowing for direct comparison under similar environmental conditions. In each plot, soil samples were collected at a depth of 20 cm, targeting two distinct microenvironments within the citrus and avocado orchards, the tree row and the interrow areas. The samples were dried at 105 °C, sieved to 2 mm, and subjected to incineration at 400 °C to determine the labile soil organic carbon fraction.

The results show that, on average, the avocado orchard soil contains more organic carbon than that of the citrus orchard. In the avocado orchard, organic carbon levels are highest in the tree rows, likely due to a continuous layer of mulch that has developed over the orchard's seven-years lifetime. Conversely, in the citrus orchard, the lowest organic carbon levels are found within the tree rows, possibly due to herbicide application. In this citrus orchard, the highest levels are observed in the interrow areas, where spontaneous vegetation is allowed to grow and pruning residues are mechanically shredded, enhancing the accumulation of organic matter.

This study suggests that permanent fruit crops allow the accumulation of soil organic carbon, and that this accumulation depends on the species grown and is different under trees and between tree rows.

KEYWORDS:

Citrus sinensis, climate change, orchard management, organic matter, Persea americana.

GT 10 - 822 - P

DYNAMICAL MODELING WITH CO-VARIATION BETWEEN SOIL ORGANIC CARBON (SOC) AND BULK DENSITY FOR SOC BASELINE DELINEATION IN PADDY FIELDS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Significant increase specified from baseline of soil organic carbon (SOC) stock should be observed for evaluation of carbon farming. Thus, baseline delineation of SOC stock is essential to certify the organic carbon (OC) sequestration in agricultural lands. The spatial variation of SOC could be referred to the processes of OC dynamics in soil. One supposes OC dynamics in soil is a random walk process and spatial distributions of OC in a site will approach to a steady state. According to the definition of SOC stock, that is derived from the paired observations of both OC and bulk density (BD) in soil, the variation in determining SOC stock includes the variations of OC and BD and the covariation between OC and BD. However, the baseline delineation of SOC stock should be satisfied with the variation of OC and covariation between OC and BD and prevented from the variation of BD. In the present study, the OC dynamical model was derived from the relationship between OC and BD observations to delineate the baselines of SOC stock for evaluation of carbon farming. Two study sites were located at Wufeng District of Taichung City (site Hsing-Da) and Chiayi City (site Chia-Da), respectively, where the rice production areas are in central-southern Taiwan. In site Hsing-Da, the soil samples were collected from the two paddy farms with conventional agriculture and organic farming. In site Chia-Da, three farms with conventional agriculture were selected for soil sampling. There were 72 soil samples from site Hsing-Da and 111 soil samples from site Chia-Da. Suppose the partial differential equation of SOC stock with respect to OC is in a function of BD. The derivative (dSOC/dOC) shows that the ratio of changes in SOC stock to OC is given the relationship between BD and OC (i.e. BD = f(OC)). The integration of BD with respect to OC was conducted to derive the baseline function of SOC stock. The results showed that the negative correlations between soil OC and BD were significantly observed for the soil samples from both sites. The non-linear model was well fitted to the relationship between BD and OC for the Hsing-Da site (fHD(OC) =0.5338*OC2 -1.472*OC +2.2572, r2 =0.7483) and the linear model was fitted to that for the Chia-Da site (fCD(OC) = -0.2542*OC+1.8465, r2 =0.6097). Then, in site Hsing-Da, the baseline function of SOC stock (i.e. FHD(OC) =3.559*OC3 -14.72*OC2 +45.14*OC -4.781) covered about 80% of the variation of SOC stock. The residual errors due to the variation of BD and random processes about 20% would result in the uncertainty of baseline function of SOC stock and associated with the mean squared error (MSE) being 3.12. In site Chia-Da, the baseline function of SOC stock (i.e. FCD(OC) =-2.542*OC2 +36.93*OC -3.579) covered the variation of SOC stock about 93% and associated with MSE =2.59. The baseline function FCD(OC) has less uncertainty. By contrast, the changes of SOC stock due to OC dynamics in soil would coincide with the baseline functions of SOC stock more well for the Chia-Da site.

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GT 10 - 852 - P

IMPACT OF ORGANIC MATTER ADDITION ON SOIL CO2 CAPTURE THROUGH ENHANCED ROCK WEATHERING

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Technosols produced from silicate rocks and organic waste have the potential to capture atmospheric CO2 and stabilize carbon. Proper mixtures lead to enhanced rock weathering (ERW) and result in more effective soil C sequestration [1]. The objective of this research is to provide proof of concept on the use of organic waste in ERW, aiming at the development of Technosols promoting efficient CO2 capture. This will increase C stocks and the fertility of agricultural soils.

For this purpose, an experiment was conducted in soil leaching columns containing mixtures of soil (50 g column-1), rocks (40 g kg-1) and organic waste (1 wt% C). The selected soil is an Albic-Umbic Podzol (Arenic), sampled in the E horizon, with the following characterization: 87.1% sand, pH H2O = 4.3; P Olsen = 0.32 mg kg-1; and Ca, Mg and Al of 0.05, 0.05 and 1.18 cmolc kg-1, respectively. Three silicate rocks were used at grinding < 0.2 mm: Amphibolite (Amp), Gabbro (Gab) and Granite (Gra). The organic sources used were livestock waste compost (19.9 wt% C; C/N 12) and plant material (45.1 wt% C; C/N 14). The design was completely randomized in a 4 x 3 factorial scheme, with 4 rock conditions (no rock, Amp, Gab and Gra) and 3 organic waste conditions (no waste, compost and plant), with 3 replicates. The incubation period was 90 days with moisture adjusted to 70% of the water holding capacity and temperature at 20 ± 2 °C. After 4, 11, 18, 54 and 90 days, the columns received 40 mL of deionized water to promote leaching and the leachates were analyzed for inorganic carbon (IC), Na+, K+, Ca2+ and Mg+2.

ERW and CO2 capture were estimated using two methods based on mass balance [2]: (i) from the sum of bases (BS = Na+ + K+ + Ca2+ + Mg+2); and (ii) from IC. Using the BS results, weathering factors of 0.0078, 0.0158 and 0.0165 were obtained for Amp, Gab and Gra, respectively. The application of plant material increased the weathering factor of the rocks between 3 and 5 times, while the effect of compost application showed greater variability. In general, higher CO2 capture values were obtained with the BS method (Figure). The sole application of rocks resulted in CO2 capture ranging from 0.08 to 0.15 g of CO2 kg-1, while higher values, over 0.30-0.40 g of CO2 kg-1, were obtained with the joint addition of plant material. The combination of compost and rocks also increased the CO2 capture, although to a lesser extent than plant material. Thus, it is concluded that the use of organic sources increases ERW and CO2 capture, especially when a more labile C source, such as plant material, is applied. Overall, the combination of rock and plant material resulted in the capture of 0.35 and 0.77 t CO2 ha-1.

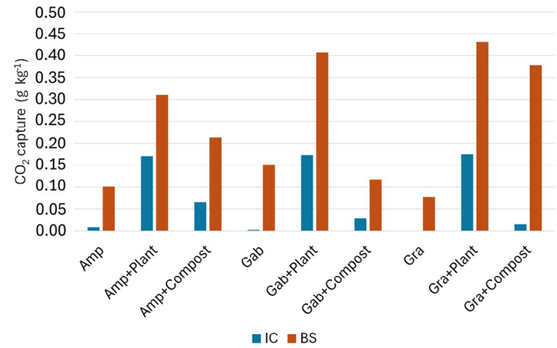
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CO_2 capture in sandy soil that received ground rocks (Amphibolite - Amp, Gabbro - Gab and Granite - Gra) and organic waste (plant material and compost), estimated through two methods: inorganic carbon (IC) and sum of bases (BS).



GT 10 - 874 - P

SHORT-TERM RESPONSE TO OLIVE POMACE-BASED AMENDMENT FERTILIZATION ON SOIL ORGANIC CARBON IN A MEDITERRANEAN OLIVE GROVE IN NORTHEAST PORTUGAL

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil organic carbon (SOC) plays a key role in terrestrial carbon storage and agricultural sustainability, especially in Mediterranean regions. This study evaluates the performance of an olive pomace-derived organic fertilizer, as a Nature-based Solution (NbS), in enhancing SOC and soil properties in a traditional olive grove (Olea europaea L., cv. Cobrançosa), established on a Eutric Leptosol under conservative management (no tillage) for over two decades. The field site, located in northeast Portugal, features a 15% slope, providing consistent and homogeneous topographic conditions, facing southwest, with approximately 200 spaced trees. The compost was applied on surface in 2022 at different dosage levels (0, 10, 20, and 40 t ha^{-1}; n = 72). SOC content was monitored over two years across different layers (0–5 and 5–10 cm depth) to assess short-term carbon dynamics.

Results showed a significant carbon increase for the first year for all dosages (27.9, 29.5 and 37.4 g kg-1, respectively for 10, 20 and 40 t ha-1) compared to control group (20.5 g kg-1), with no significant difference between doses. An opposite trend was observed for the second year, a SOC content of 22.1 and 22.7 g kg-1 was observed for doses 10 and 20 t ha-1, which was related to higher annual C loss rate of 20.8 and 23.2 %, respectively. whereas the 40 t ha-1 dose presented a significant higher concentration of carbon (30.7 g kg-1), with an annual carbon loss rate of 17.9 %. A strong positive correlation between both years (r2 = 0.86) was observed, indicating a consistent temporal pattern of SOC dynamics across treatments, despite variations in C loss rates.

These results suggest that the decrease in topsoil SOC is likely due to the mineralization of one soil C fractions, such as labile C fraction, mainly not associated with mineral fractions and, thus, unprotected from microbial activity. The lower C loss observed in the 40 t ha^{-1} treatment suggests that greater organic input may not increase mineralization in short-term. First hypothesis would be a vertical migration of C to deeper layers; however, no significant differences in SOC were found among treatments at the 5–10 cm depth in either year (mean values: 17.0 and 11.1 g kg^{-1} for years one and two, respectively). Another hypothesis indicates that instead of being mineralized, the NbS creates an environment that can favor the formation of mineral-associated organic matter within microaggregates, contributing to more stable SOC pools.

Although the preliminary results provide relevant insights, continued monitoring is essential over the remaining four years to align with the EU Soil Monitoring and Resilience Directive, thereby enabling a deeper understanding of SOC dynamics, supporting soil health assessment, and promoting evidence-based sustainable management practices in Mediterranean soils.

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GT 10 - 880 - P

LINKING CMIC:SOC RATIO TO SOIL C STORAGE IN EUROPEAN LONG-TERM TILLAGE EXPERIMENTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Agricultural soils represent an important carbon pool and, under appropriate management, have the potential to increase C storage. Promising practices for enhancing soil C stocks include replacing conventional mouldboard tillage (CT) with non-inversion reduced tillage (RT) and no-till (NT). Changes in soil organic carbon (SOC) impact microbial biomass, community composition, and activity. In this study, we investigate the relationship between SOC stocks and Cmic:SOC ratio, considering the steady-state value of 2.2 proposed by Jenkinson and Ladd (1981).

Data were compiled from 15 long-term European experiments (≥ 5 years) comparing reduced or no-till (RT/NT) to conventional tillage (CT), while accounting for site-specific experimental factors. The dataset includes soil organic carbon (SOC; n=15), microbial biomass carbon (Cmic; n=15), and basal respiration (n=8), along with metadata on soil and experimental design, management and climate (from WorldClim). SOC and Cmic stocks were calculated over the entire sampling depth using either measured or estimated bulk density and normalised using the equivalent soil mass (ESM) approach relative to CT. The resulting C stocks, the Cmic:SOC ratio, and microbial metabolic quotient (qCO_2), were compared using log response ratios (LRR) between CT and RT/NT treatments. To assess the effects of tillage on SOC stocks in topsoil and at full sampling depth, linear mixed-effects models were used. For Cmic:SOC and other soil variables, effects were estimated using soil mass-weighted averages across the sampling depth.

Under NT, both SOC and Cmic stocks increased significantly compared to CT, whereas under RT, stocks remained similar to CT for 28 and 33 paired comparisons, respectively. The Cmic:SOC ratios ranged from 0.1 % to 6.4 %; with greater variability among experiments than between tillage treatments. On average, the Cmic:SOC ratio was 1.5 (±0.81) under NT, 1.6 (±1.10) under RT, and 1.4 (±0.96) under CT. LRR analysis indicated significantly higher Cmic:SOC values under both RT and NT than CT treatments. SOC stocks were positively associated with the Cmic:SOC ratio and RT, in both topsoil and across the whole sampling depth. Organic fertilization significantly interacted with the Cmic:SOC ratio; it reduced its effect in topsoil but enhanced it across whole depth. On the other hand, RT significantly reduced the effect of Cmic:SOC on SOC stocks only in topsoil. For other factors such as no-till, mineral fertilization or soil and climatic parameters effects could not be detected due to small sample sizes or high variance.

To better understand SOC dynamics and microbial contributions across diverse pedoclimatic and management conditions, future work should prioritize improved data availability, methodological harmonization, and consistent microbial parameters use.

ACKNOWLEDGEMENTS

This work was supported by H2020 EJP SOIL - MINOTAUR (Grant Agreement no. 86269).



GT 10 - 908 - P

REDUCED TILLAGE IMPROVES AND MAINTAINS SOIL AGGREGATION AND CARBON STABILIZATION

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Carbon losses due to decomposition and erosion processes can be a serious problem in intensive crop production. The aim of this study was to investigate the effects of conventional tillage (CT), shallow non-inversion tillage (MT) after 11 years and the transition from both to no tillage after 5 years (NTct – No-till after CT; NTmt – No-till after MT) on the different organic C fractions, aggregate distribution and structural stability in two texturally different soils at 0–10 and 10–20 cm in NE Slovenia (Podravska region, near the town of Ptuj). The sites are 3 km apart and are located in the same climatic conditions (Alpine South ALS6 climatic zone) with an average annual temperature of 11°C and an average annual precipitation of 950 mm.

The soils in Moškanjci (Loamy site, L site) have a lighter texture with a clay content of 20–24% and in Mezgovci (Silty clay site, SC site) a heavier texture with 51–55% clay. The soil samples were taken at both sites in mid-October 2021, at the time of the maize harvest, at a depth of 0–10 cm and 10–20 cm. Ploughing (CT) took place 10 months before (Dec. 2020), minimum tillage (MT) at the beginning of April 2021. Samples were taken at randomly selected locations in each plot using a root auger with a volume of 700 cm3. The undisturbed samples were carefully divided into two halves, one half was dried at 40°C, ground and sieved through a 2 mm sieve for physico-chemical analyses, the other half was used to determine the Dry Aggregate Sieving Distribution (DASD). Samples were also taken using a core sampler with Kopecky cylinders to collect additional sample sets for dry bulk density determination.

In loamy soils at 0–10 cm, soil organic carbon (SOC), dissolved organic carbon (DOC), permanganate oxidizable organic carbon (POX-C), particulate organic carbon (POC) and mineral-associated organic carbon (MAOC) (<50 µm) increased with reduced tillage. In silty clay soils, the effects of different tillage were only noticeable in the SOC, POX-C and POC fractions.

Reduced tillage intensity at 0–10 cm depth had a strong influence on the distribution of structural aggregates, with CT increasing the proportion of smaller aggregates and reducing the proportion of larger aggregates. MT and NT systems increase the preservation and formation of aggregates and thus the stabilization of carbon. Reducing tillage intensity is a key factor in preventing SOC decline and soil structure degradation, regardless of texture.

ACKNOWLEDGEMENTS

We thank farms Majerič and Korošec, companies IGM Zagorje, Agromag and MRebernik. We acknowledge the Slovenian Research and Innovation Agency (ARIS) and the Biotechnical faculty, University of Ljubljana.

GT 10 - 909 - P

THE EFFECT OF IMPLEMENTING BEST MANAGEMENT PRACTICES ON THE CAPACITY OF SOILS TO MITIGATE CLIMATE CHANGE ON CEREAL FARMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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The cereal industry in Europe is extremely important because it is one of the largest sources of food and generates employment at various stages of the production chain, from agriculture to processing and marketing.

However, the disconnect between these stages hinders the implementation of the 2030 climate change mitigation and adaptation strategies set out in European environmental policies, which is a question of vital importance.

Against this backdrop, the LIFE Innocereal EU project was established with the aim of improving relationships between all stakeholders involved, facilitating the transition to a more sustainable production that reduces emissions and promotes carbon sequestration in cultivated soils.

This is achieved by analysing the effects of implementing Best Management Practices (BMPs) on the farms within the project's trial network, located on cereal croplands in Spain. These BMPs have been selected based on the climatic zone in which they are located and include the use of innovative technologies such as precision farming, guidance aids and yield monitors, as well as soil management strategies and the use of certified seed. These measures will enable farm managers to enhance their production while reducing their input usage and mitigating climate change.

The results, pending the final agricultural campaign, show the variations in soil organic carbon (SOC) stocks obtained. These variations were not always positive; some farms were found in which BMPs had not been properly implemented, resulting in losses in SOC stocks. On farms where implementation was successful the SOC stocks were improved. Increases of 0.7 t SOC/ha per year were recorded on a farm in Jerez, and 0.4 t SOC/ha per year on two farms in Seville (Southern Spain). An increase of 0.3 t SOC/ha per year was observed on a collaborating farm in Palencia (Northern Spain). In contrast, farms where BMPs had not been properly implemented showed no significant changes in SOC stocks, as seen in a farm in Valladolid, or a decrease of 0.22 t SOC/ha, as seen in a farm in Albacete. It should be noted that unfavourable weather conditions have led to low production and some farms not being harvested, resulting in lower contributions of carbon to the soil through crop residues.

ACKNOWLEDGEMENTS

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GT 10 - 920 - P

»TILLCOMP«: 24 YEARS OF TILLAGE AND FERTILISATION SHAPE SOIL CARBON AND NUTRIENTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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No-till and compost fertilisation are well-known strategies that increase soil organic carbon (Corg) stocks and contribute to changes in soil nutrients. The aim of our study was to evaluate the effects of different combinations of tillage intensity and fertilisation on Corg and nutrients (N, P, K) and their distribution in the soil (0–90 cm) after 24 years.

Soil sampling was performed in the long-term field experiment “TillComp” in Ljubljana, Slovenia. It was established in 1999 to compare four fertilisation treatments: Control without fertilisation (CON), mineral fertilisation (MIN), a combination of compost and mineral fertiliser (MIX), and compost fertilisation (ORG). The amount of compost was adjusted to the nitrogen input in MIN. Fertilisation treatments were combined with two tillage intensities: conventional plough tillage to a depth of 25–28 cm (CT), and minimum tillage, which was replaced by a no-till system (NT) in 2017.

The long-term implementation of these practices led to differences in Corg and nutrient stocks throughout soil depth (0-90 cm). The increase occurred in the same order for both tillage systems: CON, MIN, MIX, ORG.

In 24 years, compost and no-till caused significant differences of 40,3 t Corg/ha and 3,6 t/ha Ntot between NT-ORG and NT-CON, i.e. 1,7 t/ha Corg and 0,15 t/ha N per year. Ploughing increased mineralisation compared to no-till resulting in a difference of 23,3 t/ha Corg (0,97 t/ha y), and 2,4 t/ha Ntot (0,1 t/ha y) between NT-ORG and CT-ORG. Available phosphorus (AL-P) and available potassium (AL-K) stocks were highest in NT-ORG and differed significantly from all treatments. The use of compost resulted in 1,7 t/ha more AL-P on NT-ORG than on NT-CON.

The distribution of Corg , Ntot, AL-P and AL-K shows a rather homogeneous concentration in the upper 30 cm of CT, while pronounced stratification was observed under NT with MIX and ORG, particularly high in 0-10 cm. Conversely, the concentrations of Corg and Ntot were slightly higher at 30-60 cm in CT than in NT, which may be due to the incorporation of residues into the ploughing depth, which promotes the distribution of organic matter into deeper soil layers.

These results highlight the long-term impacts of combining no-till with organic fertilisation for maintaining soil fertility. The highest stocks of Corg and nutrients in ORG treatments were expected, as compost acts as a direct source of Corg, Ntot, AL-P, and AL-K. Soil disturbance caused by tillage likely contributes to lower total stocks in CT-ORG and CT-MIX compared to their NT counterparts. Stratification under NT may affect nutrient availability to crops and should be considered in fertiliser management, while deeper incorporation in CT may maintain subsoil nutrient pools. Future research should focus on the availability of other (micro)nutrients for plants and fertiliser recommendations in stratified soils.

ACKNOWLEDGEMENTS

This work was supported by Ministry of Agriculture, Forestry and Food and EU Horizon 2020 (EJP Soil).

GT 10 - 921 - P

ENHANCED BLACK CARBON DEGRADATION IN ACIDIC SOILS UNDER OXIDATIVE AGING

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Black carbon (BC), as a stable carbon pool produced by incomplete combustion of biomass, plays an increasingly critical role in the carbon cycle due to the growing frequency of forest fires. Global-scale spatial distribution of soil BC stocks can be better explained by soil properties (such as pH) rather than fire characteristics, implying that different BC degradabilities across soils may be an important factor. However, investigations into BC degradation and transformation across soil environments (particularly regarding different pH values and mineral element compositions) are still lacking. This knowledge gap limits our comprehensive understanding of global BC cycling processes and spatial distribution patterns. Addressing this key knowledge gap, this study collected forest surface soils from diverse climatic zones and employed hydrogen peroxide (H2O2) to simulate natural oxidation processes. We quantified changes in BC and dissolved BC content before and after aging using benzene polycarboxylic acid (BPCA) molecular markers method and analyzed the effects of H2O2 on dissolved organic matter composition and properties. Based on the Fenton-like reaction mechanism of H2O2 under acidic and iron-containing conditions, we hypothesized that acidic soils with high iron content would exhibit enhanced BC degradation. Results showed that under H2O2-induced oxidation, BC degradation in acidic soils were significantly greater than in alkaline soils. We found that the condensed aromaticity of BC changes more dramatically during aging in acidic soils, suggesting its structure may be more susceptible to transformation under long-term natural conditions compared to alkaline soils. Soil pH, rather than iron content, appears to be the primary factor controlling BC transformation, mainly through enhanced Fenton reactions that generate hydroxyl radicals. This study highlights that soil pH influence BC stability under oxidative conditions, contributing to our understanding of BC turnover in soil environments.



GT 10 - 926 - P

THE LONG-TERM IMPACT OF ELEVATED PHOSPHORUS SATURATION ON SOIL ORGANIC CARBON SEQUESTRATION IN FLEMISH CROPLAND SOILS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Years of intensive agriculture and fertilizer application have led to significant phosphorus (P) accumulation in Flemish cropland soils. The impact of these P concentrations on soil organic carbon (SOC) storage remains poorly understood. It is hypothesized that SOC stocks follow a bell-shaped response to increasing soil P availability [1]. Initially increasing under P-deficient conditions due to enhanced net primary production and carbon (C) inputs, plateauing as the soil organic matter (SOM) protection capacity is reached and potentially declining under excess P conditions. This potential decline may be driven by reduced rhizodeposition, increased SOC mineralization and competition between phosphate and organic anions for mineral binding sites at excess P levels.

To assess whether such a decline in SOC occurs at high P availability, the influence of the degree of phosphorus saturation (DPS) on C-stability and long-term SOC storage was assessed after approximately 30 years. The study focused on sandy, acidic agricultural soils in Flanders, where pedogenic iron and aluminum oxyhydroxides are the main sorbents for both SOC and orthophosphate. At the often strongly elevated DPS levels of these soils, we hypothesize that competition between SOC and P for these sorbents limits the stabilization of C-inputs.

Eighty-three fields were selected from a historical dataset of over 3,000 Flemish agricultural soils sampled in the 1990s. The aim was to have a subset with constant pH, clay content and phosphorus sorption capacity (PSC), but with a distinct DPS gradient. A final criterion was to have a cropping history that included maize in at least 16 of the past 29 years (the period for which crop history is available), to allow calculating a 13C mass balance to estimate the buildup of 'new' maize-derived C [2].

Soils were resampled at three depths and DPS was determined using ammonium-oxalate extractions [3] and C-content and $\delta^{13}C$ values were measured via EA-IRMS for both recent and historical samples. These analyses are currently ongoing and results are expected within a few weeks. The efficiency of conversion of maize C-inputs into maize-derived SOC fractions, accumulated over the past 30 years, as a function of DPS and other covariates, will then be investigated with a GLM.

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GT 10 - 966 - P

LONG TERM BARE FALLOWS TO QUANTIFY THE CENTENNIALLY STABLE POOL OF C UNDER CONTRASTED FERTILISER AND AMENDMENT TREATMENTS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Long-term bare fallow (LTBF) field experiments offer a unique opportunity to study the dynamics and stability of soil organic carbon (SOC) in the absence of fresh organic inputs. The Versailles 42-plots LTBF, established in 1928, is the oldest continuously managed bare fallow worldwide. Initially designed to assess the effects of various fertilisers and amendments on loess-derived Luvisols, it provides an exceptional platform to investigate the formation and persistence of a centennially stable SOC pool. It was shown that in 2008, in the reference plots of this LTBF total SOC equated with estimated centennially stable SOC (Barré et al. 2010).

Here, we took advantage of further samplings, in the reference plots, but also in all treatments, to assess whether (i) the SOC content had stabilised and (ii) the treatments affected SOC contents. We sampled the topsoil (0–25 cm) of each of the 42 plots in 2008, 2014, 2017, 2021 and analysed their SOC contents. Long-term treatments are fertilizer or amendment annual additions, including nitrogen fertilisers (ammonium, nitrate), basic amendments (lime, basic slag), mineral amendments containing P or K), an organic fertiliser (horse manure), and no-input plots, i.e. the reference plots. Archived samples from the onset of the trial had been previously analysed (Barré et al. 2010).

In all plots except those with annual manure inputs, SOC contents have stabilised over the past decades, with no significant variation observed between 2008 and 2021. These steady values show that the centennially stable SOC pool—sensu Barré et al. (2010)—has been reached.

However, the magnitude of this pool significantly differs among treatments. Plots receiving ammonium or nitrate fertilisers, or basic amendments, retained higher SOC levels than the no-input reference. In contrast, plots amended with monovalent cations (e.g. Na^+, K^+) or phosphates exhibited both lower SOC contents.

These findings support the hypothesis that soil chemical and physical environment, shaped by long-term fertilisation and amendment regimes, influenced stabilisation processes and ultimately SOC persistence. We suggest that low pHs (<5) resulting from mineral N applications can explain more SOC persisting, as well as physical protection in the calcium carbonate and lime amended plots. Poor soil structure in monovalent cations amended plots could, conversely, explain less SOC persistence.

These results demonstrate the high scientific value of long-term experiments, which need to be maintained and valorised.



GT 10 - 968 - P

COMPARATIVE ASSESSMENT OF SOIL ORGANIC MATTER QUALITY IN VINEYARDS WITH COVER CROPS AND CONVENTIONAL TILLAGE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Desertification and climate change represent major challenges for Mediterranean agriculture, especially in vineyard areas, where increasing water stress and soil degradation are intensifying their impact. In this context, cover crops represent a promising strategy to enhance soil health and improve vineyard resilience. They help prevent erosion, increase organic matter content, and improve soil structure, critical factors in areas affected by drought and extreme weather events. Leguminous species are especially beneficial due to their ability to fix atmospheric nitrogen, thereby reducing the need for synthetic fertilizers. Moreover, cover crops promote beneficial microbial communities and biodiversity. While the benefits for soil restoration and carbon sequestration are well recognized, there is still limited research on the chemical composition of soil organic carbon under these management practices.

For this study, two vineyard areas were selected: one managed with traditional tillage and the other with cover crops. Both areas share the same soil type and are planted with the same grape variety (Airén). According to the Köppen–Geiger classification, the climate is categorized as BSk, with an average annual temperature of 14°C and annual precipitation of 380 mm. Sampling points were established in each area, and soil samples were collected at depths of 10 and 30 cm. A physico-chemical characterization was performed on the soil samples, while additional samples were preserved for DNA analysis and enzymatic activity measurements. To assess carbon quality, organic matter was extracted using an alkaline solution and subsequently purified by removing the clay and salts content. Finally, it was analyzed using UV-Vis and infrared spectroscopy.

The results indicated an increase in organic carbon content under cover crop management. The analysis revealed a higher proportion of carbohydrate structures in the organic fraction of soils with cover crops. This finding aligns with the observed increase in certain enzymatic activities, such as β-glucosidase, in these soils. Genetic analysis showed a higher abundance of bacteria and fungi in the topsoil of the cover crop treatment than conventional tillage.

Overall, these findings demonstrate that carbon accumulation under cover crop management not only enhances the content and quality of soil organic matter but also increases microbial activity and abundance, thereby improving key biogeochemical properties of the soil. In conclusion, in semi-arid regions, the implementation of cover crops can significantly improve soil characteristics. By increasing organic carbon content and promoting a chemical composition that favors microbial abundance and activity, cover crops contribute to healthier soils and offer effective protection against desertification.

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GT 10 - 991 - P

IMPACT OF HIGH MINERAL PHOSPHATE APPLICATION RATES ON SOIL ORGANIC CARBON IN LONG TERM EUROPEAN FIELD TRIALS.

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Climate change mitigation calls for a deeper understanding of the carbon sequestration potential of agricultural soils. Long term positive P-balances and low P-use efficiency lead to P-saturated soils that may hinder soil organic carbon (SOC) sequestration. The relationship between long-term P application and SOC content, nature and stability remains poorly understood. High topsoil P fertility can lower root development into the subsoil, reducing rhizodeposition of carbon into these deeper layers. In addition, there may be an often-overlooked reduction of SOC protection in soil by competition with phosphate on SOC binding sites. To address these gaps, the SOC content (0-30 cm depth) from 12 archived and four new sampled European long term P trials were compiled (texture (sand to clay), pH (4.7-7.1), 16-126 years of duration). All treatments received equal, adequate doses of N and K, only mineral P rates varied. The four newly sampled trials included total SOC stocks at 0–90 cm depth. The SOC content and total SOC stocks were related to the degree of phosphorus saturation (DPS). In the archived dataset, one trial exhibited a significant decline in %SOC between the intermediate and highest P doses ($p<0.05$) coinciding with a yield plateau at those rates. Results from four of the other field trials also suggested a decline of mean SOC at high P application rates but additional sampling replicates were missing to confirm this statistically. A combined analysis of all 16 trials revealed a strong positive correlation between the %SOC reduction factor and DPS ($p<0.01$). Samples that demonstrated a significant decrease in %SOC with DPS will be analyzed for soil organic matter binding strength and biochemical composition and will be compared to samples showing an increase in %SOC with DPS. It is hypothesized that the labile to stable C ratio will be higher in the samples with a declining %SOC.

ACKNOWLEDGEMENTS

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GT 10 - 1003 - P

SOIL ORGANIC CARBON STORAGE AS AFFECTED BY PLANT-DERIVED LABILE SUBSTRATES DISENTANGLED BY A DIRT EXPERIMENT

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Temperate forests have a great potential to store soil organic carbon (SOC). Coniferous forest soils generally store more SOC in more available particulate organic matter (POM), whereas broadleaf forest soils store more SOC in more stable mineral-associated organic matter (MAOM). However, temperate forests will be affected by climate change and forest management in the future, which will most likely lead to changes in plant-derived labile substrates input to soils. Root exudates and leaf litter leachates can decrease SOC storage through increased organic matter decomposition via priming, but at the same time, they can increase it through labile C stabilisation in the soil. Moreover, soil microorganisms and fauna are expected to play crucial roles in these processes. However, to the best of our knowledge, no field study has yet focused on disentangling these effects. Here, we present results of our field experiment focused on detritus input and removal treatment (DIRT), manipulating the input of root exudates and leaf litter leachates in temperate coniferous and broadleaf forest stands. We partition SOC into POM and MAOM in topsoil and subsoil mineral horizons to disentangle the role of plant-derived labile substrates of variable quality on soil biota and SOC storage.

GT 10 - 1025 - P

A ROTHC-BASED SPATIOTEMPORAL ANALYSIS OF SOIL ORGANIC CARBON STOCKS IN AGRICULTURAL SOILS OF THE NETHERLANDS (1986–2022)

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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Soils represent the largest terrestrial carbon reservoir, with soil organic carbon (SOC) playing a critical role in maintaining soil quality, functionality and health. Despite its importance, accurately estimating SOC stocks at high spatial and temporal resolution over large scales remains challenging, particularly in agricultural systems where essential input data, such as carbon from plant residues and manure, are often uncertain or unavailable. Process-based models such as RothC are widely used to simulate SOC dynamics due to their simple structure and low data requirements. However, applying these models at high spatiotemporal resolution at national scale requires spatially explicit input data, which are often derived from proxies or substituted estimates. In this study, we used the RothC model to predict SOC stocks in Dutch agricultural mineral soils from 1986 to 2022 at 25 m resolution. Spatially explicit carbon input data were constructed from crop-specific plant residues estimated using BRP crop type maps and effective organic matter, and from manure inputs derived via the INITIATOR model, which uses farm-level livestock census data from CBS and GIAB. The objectives were to assess RothC's applicability across the Netherlands and analyze spatial and temporal patterns of SOC stocks and pools under different land uses. Results showed that from 1986 to 2022, total topsoil SOC stocks increased by 19.4% under grassland, decreased by 4.4% under cropland, and increased by 4.3% in grassland-cropland conversion area. The increase in SOC stocks in grassland systems can partly be attributed to the system being a more effective carbon sink compared to arable systems. However, grassland systems also receive systematic higher carbon inputs from manure compared to arable systems, supporting carbon sequestration in grasslands. Whereas the arable systems receive systematic much less carbon inputs, and undergo more disturbing management practices, the arable systems demonstrated to be less capable to either retain or sequester carbon and leading to a decline in SOC stocks. Carbon losses in arable systems were mainly found within the labile carbon pools, as the stable pools remained nearly constant over time. In grasslands, the stable pools increased over time, with little change in labile pools. Independent validation was performed using three spatial datasets, among which point-based field data showed the best agreement with RothC predictions (R-square = 0.29 in 1986 and 0.35 in 2022). The model exhibited limited agreement in predicting SOC changes over time (R-square ≈ 0), but reproduced key spatiotemporal patterns consistent with previous studies. Our results suggest RothC is a valuable tool for national-scale SOC stock estimation, while highlighting the need for improved input data. Future work could benefit from hybrid modelling approaches that combine RothC with machine learning to enhance prediction accuracy and better represent complex SOC processes.



GT 10 - 1028 - P

SEASONAL AND HYDROLOGICAL CONTROLS ON CARBON TURNOVER AND STABILITY IN TROPICAL WETLANDS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The molecular composition of soil organic matter (SOM) is a key to assess soil carbon dynamics in response to shifts in environmental conditions [1]. This study investigated the impact of contrasting hydrological regimes on SOM and humic acids (HA) in two tropical wetlands (seasonal and permanent) located in southeastern Brazil. Thermal and molecular analyses were conducted using thermogravimetric analysis, evolved gas analysis, and analytical pyrolysis.

The results showed that, the seasonal wetland displayed a higher proportion of recalcitrant SOM, especially during the rainy season. In contrast, the permanent wetland showed more pronounced seasonal shifts, with decreased labile fractions and increased thermal stability during the dry season, suggesting that this system, despite being permanently saturated, is more responsive to hydrological. The molecular signatures were dominated by short-chain n-alkanes (C13–C15), which reflect greater microbial reworking, while long-chain compounds (C26–C35), typically associated with plant waxes, were also present but less abundant. Lignin-derived methoxyphenols and nitrogen-containing pyrolysis products, such as pyridine and indoles, reinforced the concurrent transformation of plant residues and microbial biomass. A bimodal distribution of n-alkanes was observed in the HA fraction, while soils showed a unimodal pattern. Redox conditions influenced the distribution of alkanes between matrices, with short-chain alkanes accumulated in HA under reducing environments.

The detection of high molecular weight PAHs (>3 aromatic rings) suggests the presence of fire-specific markers, likely linked to sugarcane cultivation. These combustion residues likely contributed to the formation of recalcitrant fractions, enhancing SOM stability. The Carbon Preference Index (CPI) and S/L ratios indicated extensive microbial reworking and limited recent input of fresh plant material, particularly during the dry season.

Altogether, the findings highlight the role of hydrological regime and seasonal dynamics in shaping SOM composition, carbon stability, and turnover in tropical wetlands.

ACKNOWLEDGEMENTS

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GT 10 - 1039 - P

FLEXIBLE TEMPERATURE-DEPENDENT DIFFERENTIATION OF CARBON FRACTIONS WITH THE ELEMENTAR SOLI TOC® CUBE

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Understanding how different soil types and land management practices can increase the quantity of carbon stored in soil is increasingly important for climate change mitigation efforts. Determining the total organic carbon (TOC) content in soils provides information on the soil health, carbon sequestration potential and soil fertility. This information allows improvements in agricultural applications, environmental monitoring and other land management practices. Another recent application for TOC analysis is assessing the quality and carbon sequestration potential of biochar, a carbon rich material produced via pyrolysis of biomass for the purpose of transforming the biomass carbon into a more stable form. Biochar has emerged as a potentially promising soil amendment as it captures carbon that would otherwise be released into the atmosphere and can improve soil fertility and improve water quality.

The Elementar soli TOC® cube has been developed for the measurement of total organic carbon (TOC) and total inorganic carbon (TIC) but also the residual oxidizable carbon (ROC). The soli TOC cube uses temperature ramped differentiation of the carbon factions with a crucible-based sample feeding system, gas switching and dynamic furnace. Alongside standard applications using a 3-step temperature programmes e.g. EN 17505, the soli TOC® cube also has the option for flexible programmes with up to 5 temperature steps offering new possibilities for differentiating carbon fractions or species and for studying the temperature-dependent decomposition of carbon compounds.

We present results from the new 5 - step temperature ramping method that gives users the ability to run flexible temperature programmes under combustion or pyrolytic conditions with up to five target temperatures between 150 and 900 ºC. Other adjustable parameters include the switching time between combustion and pyrolysis, temperature ramping time and temperature hold times. This enhanced flexibility gives the opportunity to address new scientific questions with an unrestricted analysis of the different carbon fractions.



GT 10 - 1067 - P

DOES PHYSICAL OR CHEMICAL PROTECTION DRIVE MINERALISATION OF SOIL ORGANIC CARBON ON A SINGLE-AGGREGATE SCALE?

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Climate-smart agriculture and soil health targets often promote practices that aim at increasing soil organic carbon (SOC) stocks in agricultural soils. However, long-term soil carbon dynamics depend on the source of soil organic matter (SOM) as well as its turnover, i.e. mineralisation or stabilisation, resulting from complex interactions of physical, chemical and biological processes. The source and turnover of SOM affects soil aggregation, and consequently soil structure. Soil structure, in turn, affects SOM decomposition as the spatial distribution of pores and OM within the soil determine its accessibility to and activity of microbes. These two-way interactions between soil pores and SOM mineralization remain poorly understood although they can have important consequences for larger scale soil carbon dynamics. The aim of this study was to determine whether physical or chemical protection is the driving factor of soil carbon dynamics on the single aggregate scale. For this purpose, we extracted aggregates (4-6 mm) from soils of two long-term field trials, one in Central and one in Southern Sweden with different soil textures (sandy loam and clay loam) and organic matter inputs (mineral fertilization and livestock, bare fallow or straw addition). We then assessed how microbial respiration was affected by the co-location of organic matter and soil pores, as well as how chemical and physical protection affected SOM turnover. We first characterised SOM composition using solid state 13C nuclear magnetic resonance spectroscopy. Respiration rates (µg g-1 h-1 CO2-C) of moistened single aggregates were then measured using a modified MicroRespTM setup. Before and after respiration measurements, we characterised the structural properties and internal pore networks of each aggregate using 3-D X-ray micro-computed tomography (CT) with a voxel edge length of 5 µm. Thereby, we were able to compare the spatial distribution of pore networks with that of particulate organic matter to determine how physical accessibility affected microbial respiration on the aggregate scale. To map SOM within aggregates we also applied staining with osmium, a metal that binds strongly to unsaturated carbon bonds and is readily detectable using X-ray micro-CT. Additional pyrophosphate extractions allowed us to quantify organic carbon chemically protected by complexation with amorphous aluminium hydr(oxides). We expect that microbial respiration is driven by the co-location of SOM and soil pores but further influenced by the quality of organic matter and its chemical protection by complexation with short-range order soil minerals. The results will contribute to a better understanding of the small-scale mechanisms of SOM turnover that affect larger-scale organic carbon stocks in soils.

ACKNOWLEDGEMENTS

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GT 10 - 1071 - P

TEMPERATURE DYNAMICS IN RESPONSE TO DIFFERENT LAND-USE REGIMES IN SOUTHEASTERN SÃO PAULO, BRAZIL

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Land use and land cover changes in tropical regions strongly influence soil ecosystem services, surface energy balance, and carbon stocks, while directly impacting local water security. This study aims to analyze the spatiotemporal dynamics of land surface temperature (LST) and land use changes, relating them to water security indicators in a tropical agricultural frontier in the southwestern region of São Paulo State, Brazil.

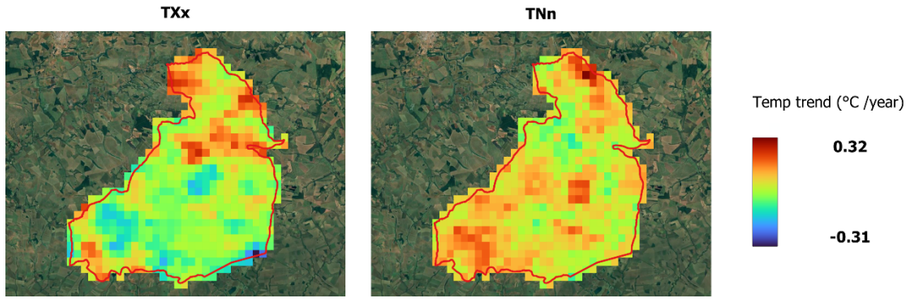
The study was conducted in the municipality of Assis (650.916 km²), located in southeastern Brazil, covering the period from 2000 to 2020. The spatiotemporal dynamics of landscape use were analyzed using land use and land cover classification maps obtained from the MapBiomas platform. To understand the impact of land use on climate regulation ecosystem services, we analyzed land surface temperature during the day, night, and the diurnal temperature range (day–night). LST data were obtained from the MODIS satellite (MOD11A1) as annual means. Land use classification data from MapBiomas and MODIS (MOD11A1) imagery for surface temperature (day, night, and amplitude) were used. Statistical analyses included normality tests, Pearson correlation, linear regressions, and the Hartigan dip test for detecting multimodal distributions. Additionally, we assessed trends in the annual maximum (TXx) and minimum (TNn) surface temperatures. Data processing and spatialization were performed using R (v4.0.4) and QGIS (v3.26.1) software.

The spatiotemporal evolution of land cover revealed a reduction in pasturelands and an increase in urban and agricultural areas. Forest cover also showed an increasing trend during the analyzed period. The reduction in pasturelands in São Paulo State in favor of croplands is related to public policies that promoted sugarcane expansion. Regarding forest cover increase, changes in the Brazilian Forest Code in 2012 have driven reforestation efforts, especially in São Paulo, to meet the new legal requirements. These landscape dynamics have direct implications for the local climate. Our results indicate warming trends in the region: annual maximum temperature (TXx) increased on average by 0.02 ± 0.08 °C per year and the minimum (TNn) by 0.04 ± 0.3 °C per year, particularly in agricultural and urban areas. Over the 20-year period, this represents an increase of approximately 0.4 ± 1.6 °C for TXx and 0.8 ± 0.6 °C for TNn, with high spatial variability. On average, surface temperature ranged from 29.85 °C to 33.85 °C in urban areas and from 23.85 °C to 31.85 °C in forested areas. Transition zones between forest and urban areas exhibited bimodal LST distributions, indicating critical zones for microclimate regulation. Overall, forested areas had lower mean temperatures and smaller diurnal ranges compared to urban areas, highlighting their essential role in regulating the microclimate in municipalities.

The results reinforce the thermal mitigation role of forested areas and underscore the need for public policies focused on land-use planning and the conservation of native vegetation in rapidly transforming agricultural landscapes.

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GT 10 - 1072 - P

PRELIMINARY RESULTS OF SOIL ORGANIC CARBON DYNAMICS EVALUATIONS ACROSS ANTHROPOGENIC GRADIENTS IN KAYA KAUMA SACRED FOREST, KENYA

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil organic carbon (SOC) is a fundamental component of terrestrial ecosystem function, essential for nutrient retention, water regulation, and long-term carbon sequestration. In tropical drylands, forest degradation due to human activity increasingly threatens these belowground carbon reservoirs. Assessing how varying levels of anthropogenic disturbance influence SOC distribution is critical for understanding soil carbon dynamics and informing sustainable land-use strategies. This study investigates SOC patterns across a human disturbance gradient in Kaya Kauma, a UNESCO-recognized sacred forest in coastal Kenya, protected by traditional Mijikenda communities. The forest was stratified into three zones, core (intact), intermediate (moderately disturbed), and edge (highly disturbed), to reflect increasing anthropogenic pressure. Ten 20 × 20 m plots were established (n = 4 in Edge, 2 in Intermediate, and 4 in Core), and soil samples were collected at four depth intervals: 0–10 cm, 10–20 cm, 20–50 cm, and 50–100 cm in early 2024. Samples were air-dried, sieved to 2 mm, and analyzed for SOC using a CNS analyzer via high-temperature dry combustion. Bulk density was also measured to calculate SOC stocks (Mg C ha^{-1}). Descriptive analysis and spatial comparisons were conducted to examine SOC variability across zones and depths. Results reveal a marked decline in SOC from the undisturbed core areas toward the more heavily impacted forest edges, underscoring how firewood extraction, grazing, and adjacent land conversion reduce the soil's carbon sequestration capacity. Core zones maintained notably higher carbon stocks, indicating the resilience of intact forest interiors. The poster will present methodological details, depth-specific SOC trends, and conceptual diagrams illustrating carbon gradients. These findings emphasize the importance of culturally protected forest systems in stabilizing carbon pools and maintaining productive soils in landscapes facing growing environmental pressures.

ACKNOWLEDGEMENTS

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GT 10 - 1089 - P

DOES THE INITIAL COMPOSITION OF ORGANIC MATTER AFFECT MICROBIAL STABILIZATION PROCESSES?

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Soils cover a large part of C stocks of the globe surface. The turnover of carbon in soil depends on the formation of soil organic matter (SOM) and its stabilization processes, which are closely linked with the soil microbial communities. Recently, Domeignoz-Horta et al. (2021) provided direct evidence for a link between microbial community structure, SOM composition, and thermal stability. The authors showed that distinct microbial communities produced SOM with different degrees of thermal stability. However, the initial composition and intrinsic stability of organic matter may as well affect microbial decomposition. In this study, we investigated the effects of the initial composition of organic matter on the microbial decomposition and the resulting microbial-derived SOM stability.

Artificial soil (10% clay) was amended with three substrates differing from their intrinsic biological stability (cellulose, chitin and suberin/cutin-derived compounds). Each mixture was inoculated with three different soil inocula made from the filtering of a forest soil inoculum (bacteria-enriched, fungi-enriched, bacteria + fungi). Microbial activity corresponded to the CO2 measurements during incubation until a plateau was reached. Fungal and bacterial copy number were assessed by qPCR of ITS and 16S rRNA gene. Thermal stability was estimated using the Rock-Eval® thermal method, consisting in the continuous measurements of hydrocarbons, CO and CO2 over temperature gradients under successive pyrolysis and oxidation stages (Behar et al. 2001).

Preliminary results showed that suberin/cutin-derived compounds were degraded more rapidly by all three inocula than cellulose or chitin. Furthermore, for all three substrates, the bacteria+fungi inoculum induced a better or similar degradation than the bacteria- and fungi-enriched inocula. We expect our study to show that different chemical composition of substrates induce different responses in the diversity of microbial communities, potentially impacting the stabilization of microbial-derived organic matter.

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GT 10 - 1102 - P

CARBON DYNAMICS IN AGRICULTURE: LOOKING FOR THE KNOWLEDGE GAPS – A SYSTEMATIC REVIEW

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The complexities of carbon dynamics are intensified under agricultural management, as this land-use type introduces multiple factors that significantly influence soil carbon pools. Due to this, over the past decade, the number of publications focused on soil organic carbon and carbon dynamics has increased noticeably. Therefore, it is essential to analyze current knowledge gaps and explore the future research directions recently proposed to promote more sustainable agricultural practices. This study aims to identify the principal knowledge gaps highlighted in review articles published between 2023 and 2025, using the Web of Science database. To conduct this review, the PRISMA 2020 protocol for reporting systematic reviews has been followed. To refine the initial dataset of 1420 articles, several exclusion criteria were applied, culminating in 179 articles that were read in detail. Consequently, the knowledge gaps on soil carbon research in agroecosystems have been classified hierarchically into six main categories: (1) perspectives to approach the subject; (2) soil carbon pools on which to focus; (3) carbon fluxes in and out of the soil system; (4) methodologies and technologies used in research; (5) interactions between carbon and other factors; and (6) spatial and temporal distribution and variation of carbon within and among agroecosystems. The results showed that the most frequently cited knowledge gaps were related to the microbial carbon pool, mentioned in 22% of the articles, and the interactions between carbon and abiotic factors, which had the same frequency. These were followed by carbon interactions with management practices (20%), temporal variation in carbon distribution (17%), and carbon fluxes related to soil stabilization processes (16%). This study underscores the critical inquiries that the scientific community should address to improve our understanding about carbon dynamics, and in the end, the management of agroecosystems.

GT 10 - 1104 - P

QUANTIFICATION OF BLACK CARBON (BC) AND ITS PHYSICAL FRACTIONATION IN URBAN AND PERIURBAN SOILS ACROSS THE METROPOLITAN AREA OF MILAN (ITALY)

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Black carbon (BC) is a recalcitrant component of organic carbon, derived from the incomplete combustion of biomass and fossil fuels. In urban environments, BC is mainly associated with vehicular traffic, domestic heating, and industrial emissions, and can accumulate in soils, where it plays a role in long-term carbon sequestration and contaminant dynamics.

In this study, we investigated BC distribution and stabilization in urban and periurban green spaces across the metropolitan area of Milan (northern Italy). Soil samples were collected from 0-10, 10-20 and 20-40 cm depth across various land uses, including public urban parks (UPC and UP, both inside and outside the historical city centre), public periurban parks (PP), periurban reforested areas (PPf), small green spaces (SGS), spontaneous forests - urban woodlands (uW) - developed over former industrial areas inside the city, and mature woodlands (W) in the hinterland of Milan. Forested areas were further grouped by age: younger than 30 years, between 30 and 80 years, and older than 80 years.

BC content was determined, following carbonate removal, through the CTO-360 method followed by CN elemental analysis. In addition, surface samples (0-10 cm) underwent physical fractionation into particulate organic matter (POM) and mineral-associated organic matter (MAOM), both for TOC and BC pools. Fractionation is currently being extended to the 10-20 cm layer.

Alongside BC, we also analysed soil pH, texture, total organic carbon (TOC), total nitrogen, and available phosphorus.

Preliminary results indicate that BC represents a significant fraction of TOC (BC0-40 cm:TOC0-40 cm = 10.3 ± 5.7 %). BC is particularly concentrated in the surface horizon (BC0-10 cm = 4.38 ± 0.54 g kg-1), where spatial variability is high, especially due to the presence of mature woodlands (>150 years), which exhibit remarkably elevated values (TOC0-10 cm = 78.43 ± 8.25 g kg-1; BC0-10 cm = 18.91 ± 3.94 g kg-1).

The relative distribution of BC between POM and MAOM varies across land uses and appears related to the distance from the urban centre. Soils from central urban parks, urban parks, and small green spaces show higher proportions of BC associated with the POM fraction (BCPOM:BC0-10 cm = 65.9 %), whereas mature woodland soils show greater BC association with the MAOM fraction (BC-MAOM:BC0-10 cm = 60.3 %).

This pattern suggests differences in BC stabilization pathways depending on soil management, organic matter dynamics, and time since deposition. In particular, the predominance of BC in the MAOM fraction in mature forest soils likely reflects enhanced stabilization due to higher organic matter inputs, microbial activity, and physical protection, whereas in urban soils, BC remains largely associated with the more labile POM pool due to limited biological incorporation and recent anthropogenic deposition.

Notably, urban woodlands exhibit high BC-POM proportions (BCPOM:BC0-10 cm = 74.3 %), likely reflecting legacy pollution from the decades of coal transport and storage in the early 1900s. In fact, in some sampling locations, visible charcoal fragments were observed in the field, supporting the hypothesis of localized BC inputs.

Abu El Khair - Abstract - final version.docx



GT 10 - 1114 - P

EFFECT OF FARMING SYSTEM ON SOIL ORGANIC CARBON STORAGE IN CITRUS ORCHARDS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 09. SOIL HEALTH

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On a planet that must move toward carbon neutrality, while ensuring food security for a growing population, permanent crops such as citrus play a dual role: capturing atmospheric carbon and producing food. Unlike other agricultural systems, permanent crops store carbon in their perennial biomass. These systems contribute organic matter to the soil over time, and by not requiring soil tillage, they promote the gradual organic carbon accumulation in the soil. However, orchard management practices, particularly soil management, can influence the soil's ability to store carbon. Different production systems, particularly organic and conventional farming, involve distinct practices regarding orchard and soil management.

To assess whether production systems can affect soil carbon storage, we used three case studies, each consisting of a citrus (Citrus sinensis) organic orchard and a conventional one, located side by side. In each orchard, we studied three soil organic carbon reservoirs: labile, intermediate, and recalcitrant carbon, at two different depths (0-20 cm and 20-50 cm), and in two microenvironments: the tree row and interrow. The samples were dried at 105 °C, sieved to 2 mm, and then subjected to sequential incineration at 400 °C, 600 °C, and 850 °C to quantify labile, intermediate, and recalcitrant carbon, respectively.

In all cases, labile carbon was the most abundant fraction, followed by intermediate carbon, with recalcitrant carbon showing the lowest values. Carbon content (%) varied among case studies, likely due to differences in soil type and management practices. All three carbon types also varied with the farming system showing higher values under organic farming, with the exception of recalcitrant carbon in one of the case studies. Total carbon ranged from 3.7% to 4.6% in organic systems and from 3.1% to 4.7% in conventional systems, likely reflecting differences in soil management practices between farming systems. Carbon content also decreased with depth, regardless of the production system, likely due to lower organic matter inputs in deeper layers. No differences were found between rows and inter-rows, unlike in other trials, which can be explained by the specific soil management practices in these case studies. These findings highlight the strong influence of soil type and management practices, particularly under different farming systems, on carbon distribution and dynamics in agroecosystems.

KEYWORDS

Carbon sequestration; Climate change; Conventional farming; Food security; Organic farming; Soil management; Soil organic matter.

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GT 10 - 1119 - P

CLIMATE AND LAND USE CONTROLS ON SEDIMENT AND CARBON DEPOSITION IN THE FLOODPLAINS OF THE KASAÏ BASIN (DEMOCRATIC REPUBLIC OF CONGO)

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Soil erosion is an important process by which organic carbon (OC) is exchanged between soil and atmospheric reservoirs; it thereby modulates atmospheric carbon dioxide (CO_2) levels over decadal to millennial time scales. Human activities, both directly in the form of land-use change and indirectly in the form of climate change, accelerate erosion and thus the mobilization of OC along the land-ocean aquatic continuum. These movements of sediment and OC through the aquatic continuum, so-called 'lateral' fluxes have an unknown effect on the global carbon cycle, which means they could either be a source or a sink of atmospheric CO_2 [1].

Floodplains may be important sites for transient sediment and OC storage of lateral fluxes, but their role has been minimally quantified. Sediments and OC can be stored for several centuries to millennia, which induces a delay between initial (upland) erosion and eventual delivery to the ocean. Floodplains are typically considered areas of organic matter preservation and accumulation due to the delivery of nutrients and fine particles combined with high net primary production in tropical wetlands, which promotes efficient stabilization of both allochthonous and autochthonous OC. Recent work has demonstrated that OC can be preserved over considerable periods, but up to 80% of this buried OC is eventually mineralized over subsequent millennia. However, most studies that have quantified the role of sedimentary environments as CO_2 sources or sinks have done so in temperate environments, leaving only limited information from tropical environments [2, 3]. This represents a substantial knowledge gap since higher average temperatures, distinct wet vs. dry seasons, unique mineralogy, and high NPP fluxes will likely fundamentally impact the OC oxidation vs. stabilization balance.

Thanks to its climatic and land use gradients, the Kasaï River Basin, largest tributary of the Congo River, presents an ideal natural laboratory for identifying controls on sediment and OC deposition. 20 floodplains from the Kasaï River floodplain and its tributaries were sampled through transects of sediment cores, in order to capture both intra-floodplain and inter-floodplain variations of deposition. Preliminary results show deposition rates ranging from 0.44mm yr-1 to 2.63 mm yr-1 as well as OC sequestration rates of 0.22-0.83 Mg C ha-1 yr-1. Controls on deposition and OC sequestration rates will further be determined both with soil quality parameters for local controls, and land use and climate patterns for regional variability.

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GT 10 - 1121 - P

A LOCAL SPECTRAL LIBRARY FROM THE KOPAIDA PLAIN, GREECE TO SUPPORT THE RAPID MONITORING OF SOIL PROPERTIES

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil monitoring is critical for understanding and managing soil health, ensuring agricultural productivity, and mitigating environmental challenges such as land degradation and climate change. Traditional methods for assessing soil properties, while accurate, often involve labor-intensive laboratory analyses that are not feasible for large-scale or real-time monitoring. This has driven the need for innovative, cost-effective, and scalable approaches to assess soil characteristics.

Hyperspectral sensing, encompassing both point and imaging sensors, has proven to be a powerful tool for soil monitoring. By capturing detailed spectral signatures, hyperspectral techniques can provide insights into a wide range of soil properties, including soil organic carbon (SOC), texture, carbonates and moisture content. Central to these advancements is the development of spectral libraries—comprehensive collections of soil spectral data—which enable robust modeling and prediction of soil properties across diverse environments.

The objectives of this study are twofold: (a) to introduce a local spectral library from the Kopaida Plain, located in central Greece, comprising of 120 soil samples and (b) to present initial modeling results utilizing this spectral library for soil properties characterization, focusing on the estimation of soil organic carbon and carbonates concentration. Soil spectra were collected under both field and controlled laboratory conditions within the visible-near infrared (VNIR) wavelength range. Soil chemical and physical properties were characterized using standard laboratory techniques, with the SOC content determined through wet oxidation methods. Different statistical models were tested, including partial least squares regression (PLSR), random forest (RF) regression and support vector regression, were employed to model SOC content using the spectral data. Variable importance analysis was conducted to identify the most influential wavelengths contributing to the predictions. Model performance was evaluated using root mean square error (RMSE), coefficient of determination (R^2), and the ratio of performance to interquartile range (RPIQ).

The results emphasize the significant potential of the developed local spectral library in accurately estimating soil properties, particularly soil organic carbon (SOC), which plays a critical role in maintaining soil health and supporting sustainable land management practices. By leveraging the advanced capabilities of hyperspectral sensing, this approach offers an efficient and scalable solution for monitoring soil conditions across diverse environments. Such innovations are vital for promoting soil sustainability, as they enable precise assessment of key soil attributes, inform targeted conservation strategies, and support efforts to combat soil degradation and enhance agricultural productivity in a changing climate.

GT 10 - 1125 - P

DISTRIBUTION OF ORGANIC CARBON FRACTIONS IN COLOMBIAN WARM CLIMATE INCEPTISOLS WITH DIFFERENT LIVESTOCK SYSTEMS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soils subjected to long-term livestock grazing experience degradation of certain physical, chemical, and biological properties, which in turn reduce forage yield and quality over time. Soil Organic Carbon (SOC) contents and fractions may be altered by land use and agronomic practices. In this study, SOC contents and fractions were evaluated in Inceptisols under different land-use practices. At La Cruz farm (University of Caldas, Anserma municipality), located at 1 030 m a.s.l., soil samples were collected on three occasions between 2020 and 2022 at depths of 0–20, 21–40, and 41–60 cm. Sampling sites included hillside pasture, flatland pasture, and a forest plot as control. SOC was quantified in coarse (>2 mm), medium (2–0.053 mm) and fine (<0.053 mm) aggregate size classes; unpurified humic acids (HA) and fulvic acids (FA) were also determined. Additionally, soil texture, bulk density (BD), total porosity (TP), pH, and exchangeable acidity (KCl 0.1 N) were measured.

Clay content ranged from 29.2 % to 32.1 %. The highest BD was recorded in hillside pastures (1.48 g*cm^{-3}) and the lowest in forest soils (0.98 g*cm^{-3}). Mean total porosity was 53.03 %. Exchangeable acidity varied minimally (4.72–4.76) across all land uses, while pH ranged from 5.40 in flatland pasture soils to 5.86 in forest soils. Overall SOC decreased with depth, from 1.89 % at the soil surface to 0.98 % at 41–60 cm. Among land uses, forest soils exhibited the highest SOC (1.47 %), followed by flatland pasture (1.30 %) and hillside pasture (1.29 %). When partitioned by aggregate size, SOC averaged 2.60 % in coarse aggregates, 3.04 % in medium aggregates, and 10.37 % in fine aggregates. Fractionation data showed that the highest SOC proportions were associated with HA (12.18–13.86 %) and FA (8.22–9.18 %), whereas the fine clay fraction contained lower SOC (6.68–8.70 %). These findings indicate that land use significantly influences SOC content and its distribution both with depth and among aggregate and chemical fractions, and that high clay contents may contribute to the stability of SOC in these soils.

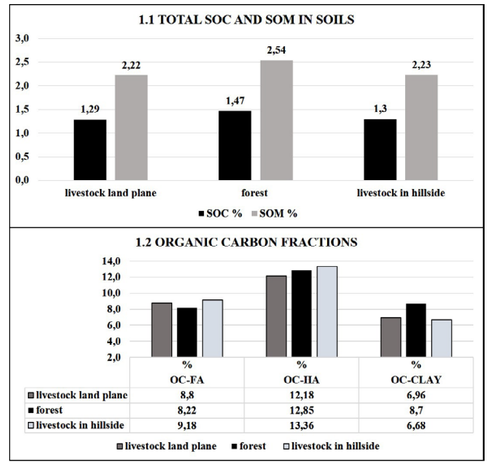
KEYWORDS

Inceptisols; Soil Organic Carbon; Grazing Soils; Humic Acids; Fulvic Acids; Land Use.

ACKNOWLEDGEMENTS

Vice-Rector's Office for Research for funding the project

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Total organic carbon in soils and organic carbon in humic fractions on soils of Colombian Inceptisols

GT 10 - 1126 - P

DISTRIBUTION OF ORGANIC CARBON FRACTIONS IN INTERTROPICAL CLIMATES IN COLOMBIAN ANDISOLS

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Distribution and quality of Soil Organic Matter (SOM) are altered by land use and management; livestock grazing, extensive cropping, and agronomic practices promote degradation of SOM, soil pH, and bulk density, while cultivated soils exhibit higher mineralization rates compared to undisturbed systems. This study assessed the effect of soil management on SOM contents and Soil Organic Carbon (SOC) fractions in Andisols under different production systems across two thermal regimes: cold (2 280 m.a.s.l., 2200 mm*yr^{-1}) and warm (1 050 m.a.s.l., 2150 mm*yr^{-1}). In the cold regime (Typic Fulvudands–Vitric Melanudands consociation), soils under avocado (Persea americana)–tree tomato (Solanum betaceum), vegetable crops, and native forest were evaluated; in the warm regime (Typic Melanudands), soils under bamboo (Guadua angustifolia), Brachiaria decumbens pasture, and maize (Zea mays L.) were sampled. Soil cores were taken at 0–20, 21–40, and 41–60 cm depths. SOM and SOC were determined by Walkley–Black in aggregate size classes > 2 mm, 2–0.053 mm, and < 0.053 mm. Bulk density (BD), soil pH (1:1 soil:water), and exchangeable acidity (KCl 1N) were also measured.

Cold climate regime: SOM contents at 0–20, 21–40 and 41–60 cm were 9.00%, 4.49%, and 3.47% in avocado–tree tomato plots; 12.04%, 5.19%, and 4.38% in vegetables; and 11.31%, 4.55%, and 3.05% in forest soils. Aggregate associated SOM averaged 5.22% in the coarse (> 2 mm) fraction, 5.63% in the medium (2–0.053 mm) fraction, and 8.96% in the fine (< 0.053 mm) fraction. BD was lower in forest (0.76 g*cm^{-3}) and avocado–tree tomato (0.88 g*cm^{-3}) soils than in vegetable plots (0.95 g*cm^{-3}). Soil pH values were 5.89 (forest), 5.91 (avocado–tree tomato), and 6.49 (vegetables), with exchangeable acidity of 5.06, 5.04, and 5.46 respectively, differences likely reflecting ongoing amendment applications. SOC associated with Humic substances comprised 9.42% in fulvic acids (FA), 8.70% in humic acids (HA), and 7.61% in the residual clay fraction.

Warm climate regime: SOM at 0–20, 21–40 and 41–60 cm depths was 4.14%, 3.35%, and 2.54% for bamboo; 4.18%, 3.40%, and 2.63% for pasture; and 3.16%, 2.48%, and 1.94% for maize. SOM in the > 2 mm aggregate fraction averaged 6.20% (bamboo), 5.45% (pasture), and 4.54% (maize); in the 2–0.053 mm fraction: 6.11%, 5.94%, and 4.45%; and in the < 0.053 mm fraction: 6.84%, 7.03%, and 6.30%, respectively. BD values were 0.82 g*cm^{-3} (bamboo), 0.92 g*cm^{-3} (maize), and 0.99 g*cm^{-3} (pasture). Soil pH was 5.69, 5.52, and 5.84, and exchangeable acidity 4.69, 4.80, and 5.18 for bamboo, maize, and pasture soils, respectively. SOC associated with HS was 11.45% in FA, 10.83% in HA, and 9.17% in the residual clay fraction. Overall, SOM was predominantly associated with the fine soil fraction; intensive management practices exacerbated the loss of fine soil particles and SOM. SOM contents and fractions were strongly influenced by climate regime, sampling depth, and aggregate size.

KEYWORDS

Andisols; Soil Organic Matter; Soil Quality; Carbon Fractions.

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Faculty of Agricultural Sciences for supporting my participation in the conference.

CLIMATE	CROP	pH		D.A.	SOC	SOM	OC-FA	OC-HA	CO-CLAY
		KCL	Water (1:1)	g*cm^3	%				
COLD	AVOCADO	4.85 b	5.41 a	0.97 a	2.33 ab	4.02 b	10.46 a	8.30 ab	7.35 ab
	FOREST	4.74 b	5.35 a	0.92 a	2.80 a	4.84 a	9.76 ab	11.19 a	9.70 a
	VEGETABLES	5.11 a	5.79 a	1.03 a	1.90 a	3.27 b	8.05 a	6.60 b	5.78 b
WARM	CORN	4.69 b	5.48 a	1.02 ab	1.76 a	3.03 a	8.46 b	8.44 b	8.54 b
	GUADUA	4.80 b	5.69 a	0.95 b	1.94 a	3.34 a	15.83 a	14.07 a	11.37 a
	GRASSLANDS	5.18 a	5.88 a	1.10 a	1.97 a	3.40 a	10.07 b	9.98 b	7.60 b

Fig 1. pH values, bulk density and organic carbon fractions in cold and warm climate andisols with different uses. Different letters indicate differences (L=0,05).

GT 10 - 1130 - P

SOIL ORGANIC CARBON DYNAMICS IN THE ERODING UPLANDS OF THE KASAI BASIN (DRC)

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 05. SOIL HYDROLOGY & EROSION

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The net terrestrial C exchange from both vegetation and soils accompanying land use change is relatively well constrained. In contrast, C exchange associated with accelerated soil erosion following the degradation of natural habitats is an uncertain component of the carbon budget [1,2,3], particularly in tropical settings [10,11,12].

The Kasai Basin, located in the southwestern part of the Congo River Basin, displays a unique array of climatic conditions, mineralogical compositions and land use trajectories. It is currently experiencing an explosive demographic expansion, which leads to drastic deforestation for cropland expansion. These changes are accelerating soil erosion on hillslopes, which plays an important role in the carbon cycle: most studies [1, 2, 3, 4, 5, …] consider the eroding uplands an important sink of atmospheric CO2, while others conclude it could be a sink or a source [6, 7, 8, 9, …].

To remedy this lack of knowledge, we conducted a robust sampling campaign and collected more than 6000 soil samples on 24 hillslope transects alongside the Kasai River across its climatic, mineralogic, and human disturbance gradients. Multiple analyses were carried out on a selection of these samples (carbon and nitrogen content and stable isotopes, soil texture, clay mineralogy, and fallout radionuclide inventory), and MIR spectroscopy was used to get high-depth resolution data. The preliminary results show a variation in SOC concentration with depth, topographic position, climatic gradients, and land use types. Across the upper 40 cm of the soil profile, SOC content ranged from 0.30% to 2.5%. Notably, a distinct 137Cs signal was detected at all sampling sites, an unexpected and encouraging result given the study's location in the Southern Hemisphere.

The results of this investigation of SOC dynamics provide insights into the different contributions of climate, land use intensity, and clay mineralogy as drivers of OC recovery in tropical eroding upland soils.

ACKNOWLEDGEMENTS

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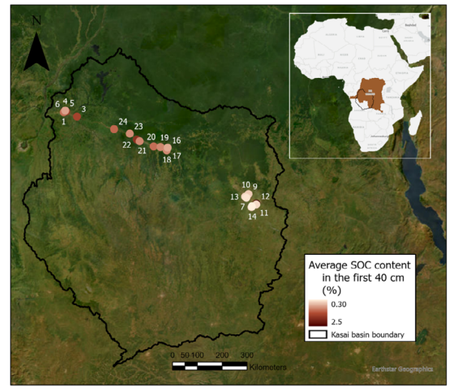
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GT10 - 1141 - P

Pore scale microbial biogeography across different soil types

GT 10. SOIL CARBON DYNAMICS AND STABILIZATION / GT 04. SOIL BIOLOGY

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Microbial activity in soils is influenced by the structural heterogeneity of the pore network, which governs the distribution of microbial communities, their interactions with organic matter and the characteristics of the immediate environment of microorganisms. This study investigates whether microbial activity exhibits consistent patterns across pore size classes in six soil types with diverse physical and chemical properties. Using a matric potential-based approach, we targeted small (3–10 µm) and large (30–100 µm) pores with 13C-labelled pyruvate to assess microbial respiration and substrate mineralisation.

The results revealed that the mineralisation of the added organic substrate was faster in the larger pores of four of the six studied soils, but that the microbial carbon use efficiency was lower compared to smaller pores, where a more efficient carbon use was observed. The exceptions were a forest soil with an abundant fungal community and a long-term bare fallow soil with depleted soil organic C content and microbial biomass. Despite differences in soil properties, such as texture, organic matter content and pH, the observed patterns were consistent across most soil types, highlighting universal controls on microbial activity at the pore scale.

This work underscores the critical role of soil microstructure in shaping microbial activity and carbon cycling. The findings advance our understanding of microbial biogeography and provide insights for improving soil carbon models to better predict ecosystem responses to environmental change.



GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 11 - 38 - O

PHYTOMANAGEMENT OF A TRACE ELEMENT-CONTAMINATED AGRICULTURAL SOIL USING AROMATIC AND MEDICINAL PLANTS TO PRODUCE ESSENTIAL OILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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To cope with the soil trace element (TE) pollution, phytomanagement was brought forward as an eco-friendly and feasible approach. To meet the dual requirements of environmental and economic performances, phytotechnologies are now combined with the valorisarion of biomass produced on polluted soils. Among the eco-innovative channels intended for the non-food valorisation of the produced biomass, the cultivation of aromatic and medicinal plants producing essential oils (EO), high-added value biosourced products, has been suggested within the framework of PhytEO and DEPHYTOP projects, funded by ADEME. Thus, this work contributed to evaluate the relevance of a management approach based on clary sage, angelica and coriander cultivation, combined or not with a mycorrhizal inoculum, on in situ experimental plots polluted or not with TE. Both clary sage, angelica and coriander have shown a good ability to settle in, to grow and to produce high amounts of biomass, despite the presence of high TE concentrations in the soil. The addition of an amendment based on arbuscular mycorrhizal fungi enhanced the mycorrhizal colonisation rates of both coriander and clary sage roots. However, no significant improvement was observed in terms of plants' growth, EO amounts and quality. Moreover, mycorrhizal inoculation allowed TE immobilisation in soils, in particular Pb, and reduced TE (Cd and Pb) transfers in aerial parts of clary sage. Besides, the EO distilled from clary sage inflorescences, angelica seeds and coriander (aerial parts or seeds) grown on TE polluted soils, displayed a highly satisfactory quality, regarding the absence of contamination by TE or pesticide residues (trace amounts). Their chemical compositions were not altered by both TE pollution and mycorrhizal inoculation and were characterized by several active principles, such as linalool, linalyl acetate, germacrene, α-pinene, γ-terpinene, 2-decenal, decanal and 2-dodecenal. Furthermore, several biological properties with potential applications in non-food fields such as crop protection (antifungal, antigerminative and herbicidal) or human healthcare (antioxidant and anti-inflammatory) have been brought forward. However, despite its ability to form inclusion complexes with EO components, β-cyclodextrin has shown no significant improvement of the tested EO biological activities. On another note, the soil revegetation with clary sage displayed a clear shaping of the bacterial and fungal communities, in both the rhizospheric soil and the roots of the aromatic plant species. Altogether, our results combined with the techno-economic feasibility assessment of the channel "aromatic and medicinal plants/EO" have emphasised clary sage as a good candidate for the phytomanagement of TE-polluted soils.

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GT 11 - 88 - O

CHANGES IN THE TECHNOSOLS PROPERTIES FOLLOWING THE AFFORESTATION OF CARBONIFEROUS PARENT ROCK MATERIAL ON THE POST-HARD COAL MINING SPOIL HEAP

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Mining for fossil fuels and minerals generates spoil heaps and open pits, which have significant environmental impacts in addition to their economic contributions. Afforestation of these disturbed areas can improve soil properties, thereby increasing the functionality and resilience of terrestrial ecosystems. However, the extent of changes in soil properties following afforestation varies depending on the methods used for tree introduction. There is a need for knowledge on the effects of afforestation on soil properties, especially in post-mining sites. Therefore, the objective of this research is to evaluate the effects of three afforestation methods: succession on barren rock top (SBT), succession on reclaimed topsoil (STS), and plantation on reclaimed topsoil (PTS) on soil properties in coal post-mining site. Soil samples were collected from 30 randomly established plots (10 × 10 m) for physical and chemical analyses, focusing on the upper layer (0-10 cm depth). The collected samples were analyzed for soil texture, bulk density (BD), porosity, air capacity, capillary water capacity (CWC), moisture content (MC), base-exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}), total organic carbon (SOCt), SOC fractions, total nitrogen (Nt), and total sulfur (St). The results showed that PTS had significantly higher CWC, Nt, Ca^{2+}, K^{+}, occluded light fraction of carbon (ColF), and mineral-associated carbon fraction (CMAF) compared to SBT. These results underscore the improvements in soil structure and organic matter content achieved through reclamation practices. Conversely, SBT had greater porosity, Mg^{2+}, and free light fraction of carbon (CflF) than STS. In addition, SBT had greater St compared to STS and PTS. This indicates that both natural succession and active restoration contribute to soil change through different mechanisms. Therefore, the choice between afforestation strategies should depend on factors such as restoration objectives, topsoil availability, and resource constraints, as active restoration is labor intensive and costly.

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GT 11 - 95 - O

IMPROVEMENT OF SOIL HEALTH AND BIODIVERSITY THROUGH THE CREATION OF TECHNOSOLS IN TAILINGS PONDS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The environmental impact caused by waste generated from mining and metallurgical activities has resulted in significant negative effects on soil, water resources (surface, groundwater, and marine), the landscape, the atmosphere, and biota. The risk of erosion by water and wind is the most critical environmental problem due to its implications. The primary objective of this study wass the creation of Technosols combined with aided phytostabilization techniques (introduction of metal-tolerant plants) in southeastern Spain to improve soil health, increase microbial abundance and biodiversity in mining tailings, and facilitate the development of a native plant cover. The restoration process involved the creation of Technosols using organic materials (slurry and manure) and inorganic materials (tailings and marble waste). The main introduced species were Piptatherum miliaceum, Salvia rosmarinus, Dittrichia viscosa, and Hyparrhenia hirta. This strategy led to an improvement in soil health, with the establishment of the introduced vegetation through planting, as well as the spontaneous colonization of native species from the surrounding areas. A 50% plant cover of grasses and shrubs was achieved, compared to the total absence of vegetation before the restoration. These results were attributed to an increase in soil pH from 4 to 7, along with a decrease in soil electrical conductivity from 2.5 dS/m to 1.5 dS/m. Soil organic carbon increased from 0.93 g/kg to 7.93 g/kg. Total nitrogen increased from 0.00 g/kg to 0.28 g/kg, available phosphorus from 0.00 mg/kg to 11.50 mg/kg, and exchangeable potassium from 4 cmol/kg to 34 cmol/kg. Soil structure improved, with a greater diameter of stable aggregates. Additionally, there was a 95-99% reduction in the availability of metals and metalloids in the soil, reducing its toxicity. This strategy led to an increase in microbial biomass from 2.75 nmol/g to 13.00 nmol/g, with a Shannon diversity index of 9.81 for bacteria and 4.57 for fungi. Thus, all soil health indicators improved through this restoration strategy, enabling the growth of a native plant cover while reducing the availability of metals and metalloids.

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GT 11 - 153 - O

CADMIUM ADSORPTION CAPACITY OF COCOA POD HUSK BIOCHAR: A SUSTAINABLE MATERIAL FOR POTENTIAL SOIL REMEDIATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Cadmium (Cd) contamination in cacao-growing soils poses a serious environmental and economic challenge, particularly in Latin American regions subject to strict European import regulations. This study evaluates the cadmium adsorption capacity of biochar derived from cocoa pod husk, an abundant agro-industrial byproduct, with the aim of exploring its potential application in soil remediation. Cocoa husks were subjected to pyrolysis at temperatures ranging from 200 °C to 400 °C. The resulting biochars were characterized using scanning electron microscopy (SEM) and attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR), and their Cd adsorption capacity was evaluated through batch experiments with a 300 ppm Cd^{2+} solution, followed by atomic absorption spectroscopy analysis.

The biochar produced at 300 °C exhibited the highest adsorption capacity, achieving 34 mg Cd/g of material. FTIR analysis identified functional groups such as carbonyls and esters, which play a key role in the chemical binding of cadmium through surface complexation. SEM analysis revealed an amorphous, porous structure, conducive to high surface reactivity. These findings suggest that cocoa pod husk biochar is a promising, low-cost adsorbent for cadmium removal from aqueous systems, with potential applicability in the remediation of contaminated agricultural soils.

This work contributes to the development of circular, sustainable strategies for managing agro-industrial waste and mitigating heavy metal pollution. Further research is recommended to assess the material's long-term stability and effectiveness in real soil conditions.



GT 11 - 202 - O

QUANTIFICATION & IDENTIFICATION OF MICROPLASTICS IN MARINE SEDIMENTS BY PYROLYSIS-GC/MS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Environmental pollution by plastics has become one of the most serious environmental issues. Microplastics may affect marine life by accumulating in the food chain and have a possible impact on human health. Therefore, analysis of microplastics in the environment is of interest. In this study, a vertical furnace pyrolyzer coupled to GC/MS (Py-GC/MS) was applied to microplastics analysis, since it provides high-sensitivity analysis and quantitative data even when the sample is a mixture of multiple polymers. The analytical workflow and instrumental setup are described. A dedicated software using a new search algorithm[1] and mass spectral libraries was applied to identify and quantify micro plastics. Software features and step-by-step workflow is demonstrated. The libraries contain 11 and 12 abundant plastic types. For easy weighing of µg scale of polymers and to consider polymer-polymer side reactions, a Micro Plastic Calibration Standard Mixture [2] was used. A dedicated micro plastic GC column setup , containing a Precolumn and analytical separation column is improving chromatographic resolution. A newly developed multifunctional sampler (MFS) for splitless pyrolysis[3] without secondary reactions is used to increase S/N ratio, thus improving limit of quantification of trace level micro/nano plastics. In this study, offshore and coastal sediment samples have been analysed. After data analysis using the micro plastic search software, various plastic types could be detected and quantified. The results demonstrate that MFS enabled Splitless Py-GC/MS can be used to identify and quantify microplastics, allowing researchers to rapidly ascertain the magnitude of the microplastic threat in environmental samples.

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FRONTIER LAB

GT 11 - 221 - O

WEATHERING OF ARSENOPYRITE IN TECHNOSOLS ON THE STORCZYKOWA MINE DUMP NEAR THE HISTORICAL ARSENIC AND GOLD MINE IN ZŁOTY STOK, SUDETY MTS. SW POLAND AND ITS IMPLICATIONS FOR SOIL CONTAMINATION WITH TOXIC TRACE ELEMENTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The study aimed to determine the effects and directions of arsenopyrite weathering, as well as total concentrations of selected trace elements in technogenic soils developed on the Storczykowa dump of the historical Au and As mine in Złoty Stok, Sudety Mts., SW Poland. The results were the basis for discussing the mineralogical effects of decades/centuries of mine waste alterations in the soil environment and the potential environmental hazards related to releasing trace elements (with particular emphasis on arsenic) into the soil. Basic soil properties were determined using standard pedological methods. Total concentrations of elements were measured using the ICP-MS technique. The mineral composition was analysed using the X-ray diffraction method (XRD). Thin sections from selected soil samples were examined using a petrographic microscope, scanning electron microscope – energy dispersive spectrometry (SEM-EDS), and electron probe microanalyzer (EPMA). The Zeien and Brummer method was used for sequential extractions of metal(loids) in soils.

The studied soils were taken from the surface of the dump at depths of 0–10 and 10–20 cm. They had sandy loam and loamy sand texture. The soils were characterized by the following properties: pH (4.1–7.0), total organic carbon content (0.17–14.0%), total nitrogen content (0.06–0.67%), and total sulphur content (0.06–0.26%). Smectite was a predominant mineral in the soils, followed by quartz, chlorite, mica, feldspars, and amphibole. Total concentrations of As ranged between 1291 and 67450 mg·kg-1. Soils also contained high concentrations of Au (0.16–3.99 mg·kg-1), Cu (21.1–1177 mg·kg-1) and Fe (3.8–19.3% of Fe2O3). The sequential extraction of As showed that the percentage of easily soluble, exchangeable and MnOx-bound differed in soils and ranged between 5 and 39% of the total As concentrations. Although the proportion of easily soluble forms was marginal (max. 1.7%), it actually indicated that up to 373 mg·kg-1 could be released to the pore water. The highest percentage of As in relation to its total content was associated with the fractions bound to organic matter, as well as amorphous and crystalline FeOx.

Such high metal and metalloid contents were related to sulphides in the parent material. Arsenopyrite was the most abundant sulphide mineral in soils. Apart from As, Fe, and S, it contained admixtures of Se, Sn, Co, Zn, Pb, Cu and Au. Unweathered arsenopyrite grains were rarely found in soil material. Most of those grains were transformed into partial or full pseudomorphs of Fe oxides after sulphides. Arsenopyrite weathering led to the release of Fe, which crystallized in the form of Fe oxides. These oxides were strongly enriched in As (up to 34%). They also contained a considerable admixture of Ca (up to 10%).

ACKNOWLEDGEMENTS

The study was financially supported by the Polish Ministry of Science and Higher Education.



GT 11 - 222 - O

AQUEOUS FOAM GENERATED IN SITU FOR TOP SOIL REMEDIATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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Chemical or radioactive contaminants accumulate in the top soil horizon (0-50 cm) depending on their ability to migrate. It is particularly the case of radioactive cesium spread around accidented nuclear power plant (more than 10 000 km² in the case of the Fukushima-Daiichi accident) that contaminated durably the first 10 cm of the top soil, by being adsorb in clay particles [1]. Following this contamination, several million m3 of soil were excavated and treated using ex situ remediation technics. Subsequently, the development of complementary in situ methods is necessary to manage this contamination with less expensive and safer remediation process.

In 2024, an innovative process was patented at the CEA [2] using a flow of foam generated in situ to extract fined-sized phyllosilicates particles durably contaminated by cesium. The porosity network of an unsaturated soil allows foam to be generated in situ by mixing a foaming liquid with an air flow generated by aspiration or air vacuum (suction) from the soil surface. Micron sized (1-30 µm) phyllosilicate particles can be mobilized, extracted from the soil and recovered from its surface using the same in situ foam ascendant flow (Figure 1. a).

As a laboratory proof of concept, a new portative device designed to treat the top soil horizon (0-10 cm) without compressed air supply was developed. Particle transport experiments were conducted on soil models using uncontaminated illite particles adhered to sand particles as a porous medium. Then, to study this kind of in situ foam flow in a porous media at a local scale, a FOAMSCAN™ analyser from Teclis Instruments was adapted to study the influence of throat pore size and foam flow velocity on particle detachment and ascendant transport (Figure 1. b).

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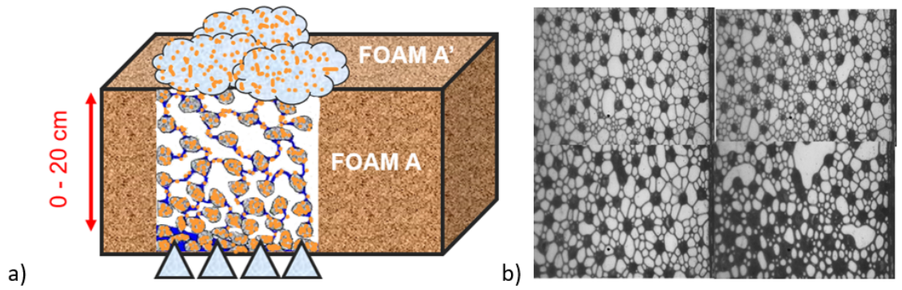


Figure 1. a) Concept of an ascendant in situ foam flow for phyllosilicates particles recovery, b) Foamscan observation of the lamella network of an ascendant foam flow generated in situ in a 1 mm monodisperse glass beads stack.

GT 11 - 241 - O

RISK ASSESSMENT OF THE PRESENCE OF IONOPHORE ANTIBIOTICS IN AGRICULTURAL SOILS BY MEANS OF THE LEUCINE INCORPORATION TECHNIQUE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The risk assessment of soil pollution has been traditionally determined by ecotoxicity tests using non-native single or multi-microbial species, which are neither representative of all soil microorganisms nor do they reflect in situ conditions. The thymidine/leucine incorporation techniques (1), a novel ecotoxicology assay using directly the soil bacterial communities, have been developed and successfully used in the last decades to evaluate the potential toxicity of different inorganic and organic contaminants in soils. However, despite its interest, the use of this assay of great ecological relevance in soil toxicity studies is still scarce. In the present investigation, the risk assessment of the presence of four ionophore antibiotics widely used in animal production (monensin, salinomycin, lasalocid and narasin) was evaluated in agricultural soils showing different pH and organic matter content (Galicia, NO Spain) using the leucine incorporation technique. Briefly, the bacterial communities were extracted from soil and separated into different aliquots which were added and non-added (control soil) with a wide range of antibiotic solutions whose concentration ranged from giving no inhibition to total inhibition of the leucine incorporation. The bacterial growth was measured, and the IC50, IC10 and IC90 values, the antibiotic concentrations resulting in a growth inhibition of the control soil of 50, 10 and 90 per percent, respectively, were calculated using the logistic model. The data showed sigmoidal dose-response curves (bacterial growth decreased with increasing the antibiotics concentration) for 4 antibiotics in all studied soils, demonstrating clearly the toxicity of these antibiotics for soil microbial communities. Furthermore, IC50 values were positively and significantly related with IC10 and IC90 values. Data also showed different toxicity indices depending on both the antibiotic and the soil considered. The pH rather than organic matter content was more decisive for the toxicity of antibiotics to bacteria. In general, the toxicity indices showed that lasalocid and salinomycin were more toxic than narasin and monensin. The study clearly demonstrated that the leucine incorporation technique has great potential for evaluating the risk assessment of these emergent contaminants in soils. To our knowledge, this is the first attempt to evaluate the impact of these ionophore antibiotics derived from veterinary use on soil microbial communities.

ACKNOWLEDGEMENTS

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GT 11 - 281 - O

ASSESSMENT OF SPATIAL AND VERTICAL DISTRIBUTION OF HEAVY METALS IN AGRICULTURAL SOILS OF MIDLAND MOROCCO: ECOLOGICAL AND HEALTH RISK IMPLICATIONS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Potential toxic elements (PTEs)contamination in agricultural soils represents a major environmental concern, posing significant threats to ecosystems and human health. This paper investigates the spatial and vertical distribution of heavy metals in soils from key agricultural regions in midland Morocco, focusing on their sources, ecological risks, and implications for public health. We assessed concentrations of As, Cd, Cu, Mn, Pb, and Zn across five soil profiles representing different soil types, including Calcisols, Vertisols, Luvisols, and Phaeozems, analyzing their availability using DTPA and CaCl extraction methods. Additionally, mineralogical analyses were performed using X-ray diffraction (XRD) to further characterise the soil composition and metal association. Our findings demonstrate elevated levels of As, Cd, Pb, and Mn, highlighting significant anthropogenic influences from agricultural inputs, notably fertilizers and pesticides. Moreover, the combined use of statistical analysis and XRD revealed that while some metals such as Cd and Pb are mainly anthropogenic, others like Mn and Zn are predominantly geogenic.

Additionally, distinct vertical variations in metal concentrations reflect their differential mobility and accumulation behavior in response to soil characteristics and anthropogenic activities. This work provides a comprehensive assessment of both vertical and spatial distribution of heavy metals by examining full soil profiles across different soil types, an approach not previously applied in this context, integrating advanced statistical tools and ecological and health risk evaluations. Identifying critical contamination pathways through the soil profile provides essential insights for mitigating risks associated with heavy metal pollution in agricultural systems.

ACKNOWLEDGEMENTS

This research was funded by the Center of Excellence for Soil and Fertilizer Research in Africa (CESFRA), Mohammed VI Polytechnic University (UM6P).

GT 11 - 291 - O

POLYPROPYLENE AND POLYESTER MICROFIBERS: A HIDDEN THREAT IN SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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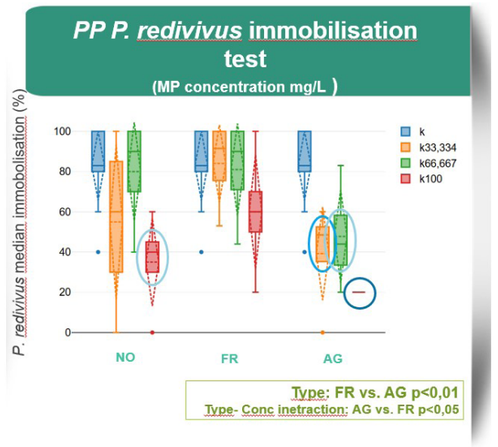
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Microplastics are defined as plastic particles ranging from 0.1 to 5000 µm in size, originating from the fragmentation of waste and consumer products (secondary microplastics) or deliberately manufactured at this size (primary microplastics). Due to some improper agricultural practices, such as the mismanagement of agricultural mulch films or the application of sewage sludge as fertiliser, contamination of soils by microplastics often exceeds that of natural water bodies. Toxicological studies on microplastics are often conducted in non-environmentally relevant test systems, disregarding factors such as the actual size and shape, ageing and chemical contamination of microplastic particles present in natural settings. In our experiments, we investigated polyester (PES-P6/15; 16-20 x 1300-1900 µm; Goonvean Fibres Ltd., UK) and polypropylene (PP-DA3/15; 22 x 3000 µm; Goonvean Fibres Ltd., UK) microfibers, which are among the most common plastic contaminants found in soil. The microfibers were tested in three forms — intact, mechanically fragmented, and aged — under 24 and 48 h exposure periods in three concentrations (33.3, 66.6, 100 mg/L MP). During the experiment, the animals were fed 10 µl of kefir suspension. The fragmentation (cryo minced) and the ageing processes (Q-SUN Xe-1-SE chamber, 0.35 W/m2 irradiance using daylight filter at 340 nm, 60°C air chamber temperature, 8/16h UV/dark cycles, 14d) were intended to simulate environmental degradation. We assessed the sensitivity of the nematode Panagrellus redivivus to these microplastic exposures. Microplastic particles negatively affected the motility of the nematodes, with the most pronounced immobilisation observed at the lowest concentration in aged P6/15. This effect was likely due to fiber entanglement at higher concentrations, reducing the bioavailability of the material. No significant differences were detected between the different forms of P6/15. In the case of DA3/15, aged particles were found to be the most toxic in a concentration-dependent way. This was presumably due to the bacteria binding to the altered surface to a greater extent, making the particles more consumable for P. redivivus. In addition, the amount of chemicals released from MP may have increased due to ageing. Further research is essential to validate these findings, including more sensitive test endpoints (e.g., J2 larval stages, lifelong tests) and longer exposure durations (up to one week).

ACKNOWLEDGEMENTS

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P. redivivus immobilisation test with PP



GT 11 - 304 - O

ARTIFICIAL SOILS AS A PROMISING CDR AND LAND RESTORATION STRATEGY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The C-Sink project investigates the feasibility of several Carbon Dioxide Removal (CDR) technologies [1]. One of them is Artificial Soils (AS), a novel strategy that may contribute to the mitigation of greenhouse gases (GHG) emissions while simultaneously restoring degraded land [2]. The EU-funded project comprises an AS field pilot in David Mine (A Coruña, Spain), an active open-pit dunite mine located in the northwest of the country.

Six pilot plots (300 m2 each) were formed by a deep layer of dunite residues and a superficial layer (15 cm approx.) made either of fine-grained dunite (two control plots) or an AS mixture (four plots). The AS consisted of a mixture of bio-stabilised organic residues and construction and demolition waste. Different additional amendments were also used in the four AS plots: biochar, dunite residues, both, or none. Three months after implementation, all the plots (except one of the controls) were sown with grasses and planted with birch and oak saplings. A two-year comprehensive monitoring of the plots includes edaphic, chemical, microbiological, botanical and remote sensing studies.

Preliminary results indicate that vegetation has a strong influence on carbon dynamics, and that organic carbon may percolate from surface layers to deeper soil strata. Fingerprinting method ARISA (Automated Ribosomal Intergenic Spacer Analysis) distinguished between the microbial communities of the AS plots and those of the controls, the latter displaying lower biodiversity. Differences were also observed in control plots microbial communities sampled in different seasons of the year possibly due to abiotic factors such as climate variations. The AS matrix may buffer these influences, offering a more stable environment for microbial communities. Further research, including a metagenomic analysis, is planned. Both qualitative and quantitative data reveal higher biomass development in AS plots compared to controls.

In summary, preliminary data suggest that Artificial Soils represent an effective land restoration strategy, promoting microbial biodiversity and biomass production. Synergistic effects between other CDR strategies, such as Enhanced Rock Weathering or biochar, may further enhance CO2 sequestration and restoration outcomes. Although total carbon, especially its organic fraction, increases with AS application, high in organic matter, further research is required to evaluate its efficiency as a CDR method, considering the unique pedogenetic processes involved in AS formation and evolution.

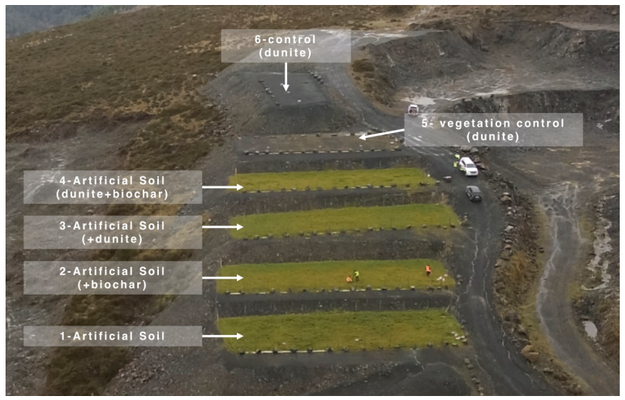
ACKNOWLEDGEMENTS

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Pilot plots and their composition.

GT 11 - 349 - O

THE RISK OF SOIL SALINIZATION ALONG THE RIVER WERRA IN GERMANY AND ITS POTENTIAL IMPACT ON SOIL STRUCTURAL STABILITY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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Globally, more than 800 million hectares of land are affected by soil salinization [1]. Since the most severe forms of soil salinization occur in arid and semi-arid climates, there exists a research gap regarding soil salinization in temperate climates. We addressed this research gap, guided by the following questions:

Are soils of temperate climates also threatened by soil salinization, especially anthropogenic soil salinization? What are the main factors driving the persistence of salts in these soils? How do more frequently occurring floods and droughts, due to climate change [2], affect these dynamics?

As the target area of our research, we chose the floodplain soils along the Werra in Germany, a river that is heavily impacted by salt inputs from the potash industry. Magnesium concentrations in the river reach up to 235 mg L-1 [3].

Between 2020 to 2022, soil samples were taken from five different depths: 0 – 20 cm, 21 – 40 cm, 41 – 60 cm, 61 – 80 cm and 81 – 100 cm. During that time no major flood event occurred, but the area was affected several times by summer drought.

In order to assess the salinization of the soils, electrical conductivities (ECs) and the concentrations of Na+, K+, Mg2+ and Ca2+ were measured in soil saturation extracts. Furthermore, the exchangeable cation concentrations of Na+, K+, Mg2+ and Ca2+ as well as the potential cation exchange capacity were determined according to the method of Mehlich.

Cations such as Na+ and Mg2+ with a lower valency or a larger hydrated radius tend to bind more loosely to the sorption complex of the soil and thus can reduce the binding strength between soil particles [4,5]. When the saturation of the exchange complex with Na+ and Mg2+ exceeds certain percentages, a significant deterioration of the soil structure through swelling processes and soil dispersion becomes more likely. Both processes lead to a reduction of the diameter of soil pores [5,6].

To determine changes in soil structural stability, different percolation experiments were conducted. In Variant 1, the different soil samples were percolated with deionized water to simulate natural dilution processes and the reaction of the soils to it.

In Variant 2, the soil samples were percolated in the same way as in Variant 1, but with saline water that resembles the composition of the river water during a flood. By this means, we simulated the conditions of a flood event and the reaction of the soils to it.

To address changes in soil structural stability the percolation rate was measured. Furthermore, the turbity of the percolates, as a measure for soil dispersion, was determined.

The comparison of both variants revealed clear differences in percolation rates and turbidity, which cannot only be explained by percolation solution, but also by standard soil parameters. The driving factors for the interactions were texture and soil organic matter.

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GT 11 - 357 - O

SOIL PHYSICAL RESPONSES TO GRAZING AND VEGETATION HETEROGENEITY IN THE PATAGONIAN STEPPE: ASSESSING DEGRADATION AND RESILIENCE AT MULTIPLE SPATIAL SCALES.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Patagonian rangelands, which encompass a diverse array of arid and semi-arid ecosystems, are increasingly affected by livestock-induced degradation, particularly due to prolonged grazing. This study assessed how vegetation type, grazing management (long-term exclusion vs. active grazing), and microsite structure (patch vs. inter-patch) influence key physical soil properties in the Chilean Magellanic steppe. Fieldwork was conducted across five plant communities—Tussock Grass, Shrub + Tussock Grass, Dwarf Shrub Heath, Small Grasses, and Wet Meadows—each representing different stages of ecological condition and grazing pressure.

Soil bulk density, penetration resistance, total porosity, and moisture content were measured, and their responses to grazing and vegetation structure were analyzed using ANOVA models. Significant three-way interactions (plant community × management × microsite) were observed for bulk density and penetration resistance. The most compacted soils (penetration resistance > 2000 kPa) occurred in Tussock Grass and degraded Small Grass communities under active grazing, indicating a critical threshold for soil degradation. In contrast, long-term grazing exclusion (up to 37 years) resulted in marked improvements in soil structure, including a 57% reduction in bulk density in inter-patch areas of Tussock Grasslands.

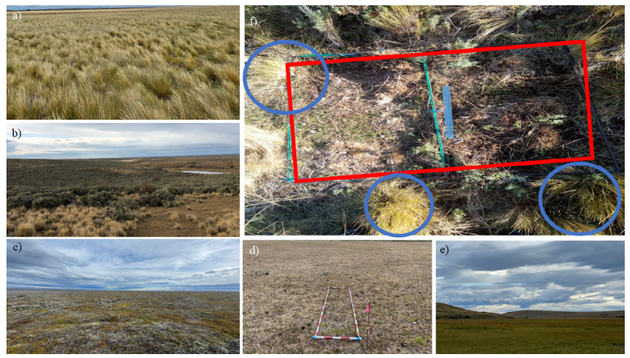
Inter-patch microsites consistently retained higher soil moisture than vegetated patches, a pattern attributed to lower evapotranspiration. Wet Meadow soils exhibited unexpectedly high bulk density (> 0.5 Mg m^{-3}), possibly reflecting degradation, supported by the presence of Azorella trifurcata—an indicator species of wetland deterioration. Total porosity and organic matter content varied significantly among communities, with Dwarf Shrub Heaths showing the highest porosity and moisture levels, especially under exclusion.

These findings highlight the role of microscale vegetation heterogeneity and management in shaping soil physical condition. The study underscores the resilience potential of Patagonian soils under proper exclusion regimes and the utility of soil indicators—such as bulk density and penetration resistance—for detecting early signs of degradation. Integrating these physical soil parameters into rangeland monitoring protocols can improve the detection of degradation thresholds and support evidence-based decisions for sustainable livestock management in heterogeneous landscapes.

ACKNOWLEDGEMENTS

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GT 11 - 377 - O

MICROPLASTIC TRANSPORT IN SOIL BY NEMATODES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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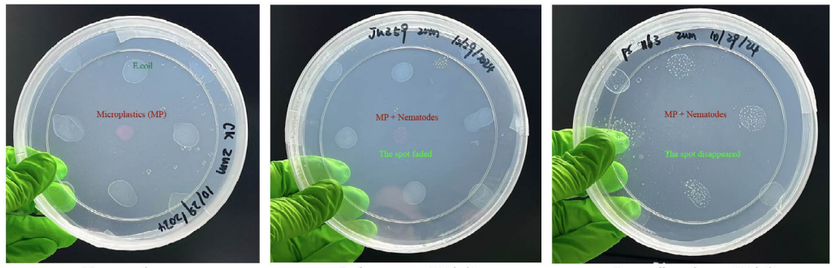
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The ubiquitous distribution of microplastics (MP) has emerged as aglobal environmental concern, amplified by their migration into soil through various pathways, including water flow and bioturbation. As the most abundant animals on Earth, soil nematodes are vital to soil ecosystem functioning and may also influence the spreading of the smallest MP in soil, which remains underexplored. Here, we examined transportation of small MP (≤10µm) by several bacterivores nematode species, and examined the underlying mechanisms using Petri dish experiments. All tested nematodes significantly enhanced the spreading of MP from the center of the dishes, with smaller MP (1 and 2 µm) transported further than larger ones (5 and 10 µm). Over 21 days of cultivation, Caenorhabditis remanei showed the highest transport capacity, moving 10 ng of MP at a mean distance of 3.56 cm for 1 µm MP, 3.73 cm for 2 µm MP, 1.03 cm for 5 µm MP, and 0.45 cm for 10 µm MP. Behavioural observations revealed that all nematodes ingested and defecated 2 µm MP and transported 1-10 µm MP through surface adhesion to, and detachment from the cuticle. Cuticle adhesion emerged as the primary mechanism for nematode mediated MP transport. The relationship between nematode traits and the transportation of 2 µm MP was further examined across nine nematode species. Correlation analysis indicated that the nematodes' ability to transport MP was significantly associated with their mobility ($r = 0.881$, $p = 0.002$) and minimum body length ($r = 0.760$, $p = 0.018$). This study provides the first evidence that nematodes may play a crucial part in the redistribution of small MP. Similar transport mechanisms of MP are likely to occur also in (especially light textured) soils, and nematode mediated MP transport in soil is currently ongoing, and will also be presented.

ACKNOWLEDGEMENTS

The financial support of the Science Foundation Flanders (FWO) through the fundamental research project grant G0B6223N and the China Scholarship Council (CSC), China, for Yin Liu [CSC No. 202207565010] is gratefully acknowledged.

Nematodes as Microplastic Vectors: 2 µm Particle Transport in 24 Hours



No nematodes | *Diploscapter sp.* (500 ind.) | *Panagrellus redivivus* (500 ind.)



GT 11 - 403 - O

TRACKING PFAS IN SOIL - DEVELOPMENT OF PFAS EXTRACTION METHOD AND ANALYSIS BY ELECTROCHEMICAL SENSORS DEVICE SPE-MIP VS HPLC

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Since the mid-20th century, PFAS have been widely used in products such as nonstick cookware or firefighting foams, leading to their widespread presence in the environment (1). Among PFAS, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS) have been the most extensively used and studied due to their widespread application in industrial and consumer products. Persistence of PFAS in the environment inevitably leads to human exposure — primarily through contaminated food, drinking water, dust and in blood serum and tissues worldwide. For example, a study conducted in Spain (2) analyzed blood samples from 755 adults and reported average concentrations of 1.99 µg/L for PFOA and 7.67 µg/L for PFOS.

A regulation under the EU Drinking Water Directive (2020/2184) sets limits of 100 ng/L for individual PFAS and 500 ng/L in total. However, PFAS contamination in soils remains largely unregulated — even though soils act as a significant reservoir for these substances - mainly due to the complexity of soil analysis and the lack of standardized methods.

Our work focuses on developing an analytical procedure for quantifying PFOA and PFOS in soils, with on-site experiments carried out in Murcia (Spain) and Volos (Greece). Soil samples from both locations were initially uncontaminated by PFOA or PFOS. The soil in Murcia is loamy, while that in Volos is clay-loam. Both are alkaline and have similar organic matter content, providing a consistent basis for comparative analysis. To ensure optimal extraction and recovery of these compounds, we have designed an extraction protocol, currently undergoing fine-tuning to adapt it from laboratory to in-field scale (Fig. 1). It involves several steps, starting with the extraction phase, where the soil is treated with methanol as the organic solvent. Following this, an agitation step is employed to ensure thorough mixing and enhanced extraction efficiency. For further purification and concentration of the target analytes, the extracts undergo treatment with Envicarb and Solid Phase Extraction WAX cartridges. After the extraction and clean-up steps, the extracts are analyzed using liquid chromatography combined with ultraviolet detection and tandem mass spectrometry. Finally, an internally developed sensor based on a molecularly imprinted polymer (MIP) electrode (3) is employed for the sensitive detection of PFOA. Unlike conventional techniques, this IoT sensor enables rapid and on-site detection, relaying the measurements to the data cloud, thus addressing a critical need for real-time PFAS monitoring - a goal of the European project E-SPFDigit, through creation of a digital platform for remote monitoring of soil and plant contaminants, including PFAS.

ACKNOWLEDGEMENTS

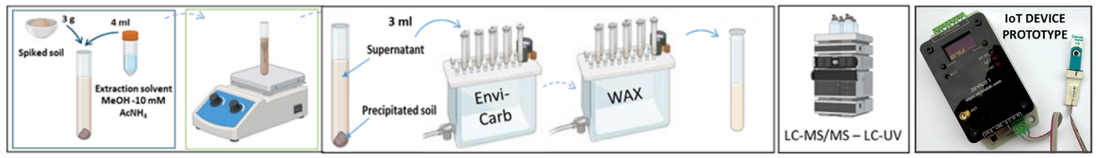
Work funded by E-SPFDigit (GA 1011579222, www.e-spfdigit.eu). Thanks to Nadège BLON for technical support

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Summary of the extraction steps and analysis protocol currently under optimization for integration on a drone/robot

GT 11 - 470 - O

POTENTIAL OF DIGESTATE-DERIVED VERMICOMPOST TO BEHAVE AS PESTICIDE ADSORBENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Intensive and super-intensive agriculture practices expose the soil to the risk of degradation and compromise the quality and safety of agricultural products. The progressive reduction of the organic fraction of the soil, including the biotic component, compromises not only the fertility and quality of the soil but also its self-depollution capacity. On the other hand, the need for energy transition to address climate change has promoted the bioenergy sector and the various processes for converting waste biomass into energy. In addition to producing biogas, the anaerobic digestion treatment releases a solid by-product, the digestate, which can be used as such as soil amendment or after bioconversion into compost and vermicompost (VC). The valuable contribution of VC to the overall fertility of the soil is well known, while its ability to interact with pesticides and control their bioavailability has been much less investigated. In this study, a VC derived from mixed digestate was characterized and evaluated for its adsorptive capacity towards two widely used pesticides, the herbicide S-metolachlor (S-MET) and the fungicide penconazole (PEN). The elemental composition of VC showed high contents of P, S and Ca and appreciable levels of important plant micronutrients, such as Mn, Fe, Cu and Zn. SEM-EDX images of VC revealed a heterogeneous surface and low porosity, while BET analysis showed a surprisingly large surface area (~1.6 m2 g−1). In batch experiments, the adsorption/desorption capacity of VC was evaluated by conducting adsorption kinetics and isotherms and modeling the data obtained. Both pesticides were rapidly adsorbed onto VC reaching the steady state in about 4 h according to a preferential pseudo-second order kinetics, which suggested the formation of chemical bonds between the interacting species. The Freundlich adsorption constants of PEN and S-MET were 2.62 and 1.19 L g−1, respectively, while the corresponding desorption constants were significantly higher for both compounds, indicating a poor and slow release of the compounds, i.e. a hysteretic phenomenon. The overall results obtained indicate that, in addition to the organic enrichment, VC can replace, at least in part, the native organic matter lost also in the retention of pesticides. This is of great relevance for the containment of soil pollution and for the limitation of the uptake of pesticides by plants and their transfer into the animal and human food chain.

ACKNOWLEDGEMENTS

This study contributes to the project PRIN 2022 PNRR titled “Microbially enriched biosorbents from waste recycling and soil-resident fungi as novel and sustainable tools to mitigate soil pollution by chemicals of emerging concern and prevent their entry and accumulation in vegetables”, financially supported by the European Union—NextGenerationEU—PNRR—Mission 4, Component 2, Investment 1.1. CUP:H53D23010520001.



GT 11 - 502 - O

ENHANCING URBAN GREEN MANAGEMENT FOR CLIMATE CHANGE MITIGATION: EFFECTS OF BIOCHAR ON SOIL CO_2 FLUX, CARBON STORAGE, AND WATER USE EFFICIENCY IN MONZA PARK

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The urban green areas, such as recreational zones and parks, are particularly vulnerable to climate change impacts as the vegetation and the soil properties of these areas can be significantly affected compared to the other areas. There is a great need for practices and amendments that can help in mitigation of those areas from climate change. In this respect, there has been a great emphasis on biochar as a soil amendment

recently. It is an end product obtained at the pyrolysis of biomass at high temperatures, usually between 300-900 °C. There is a significant amount of literature material that defines its potential for enhancing the carbon storage, water use efficiency, along with other soil properties, and CO2 efflux reduction. For this matter, a study was designed in the Monza Park at a grassland study site area of 75x50 m2. A weather station was built near the study site for taking the monthly atmospheric measurements. Lysimeters were installed in each of the six plots for the water storage measurement of the soil. The area was further divided into 6 blocks and 18 subplots of 2x2 m, with three subplots for 3 replicates within each block. Soil physicochemical properties including soil organic carbon and water retention, were measured. Initial measurement of CO_2 efflux was measured by parameters of Net Ecosystem Exchange (NEE), light measurement 2 cycle, and Ecosystem Respiration (ER), dark measurement 1 cycle per subplot from the soil was measured using IRGAs (Infrared Gaseous Analyzer), each 7-10 days from January 2025 onwards. Biochar produced from feedstock derived from wood origin was applied to the soil using the hole application method for the least disturbance of vegetation at the rate of 5,10,15,20,25 t/ha. The study aims to assess the application of biochar at different rates to determine which amount will be suitable for the reduction of CO_2 efflux from soil, along with enhancing the soil carbon content and water retention of the soil of the Monza Park. Thus, it adds to the enhancement of the soil properties of the urban green areas and the mitigation of CO_2 efflux from the urban green.

KEYWORDS:

Urban green, Biochar, CO_2 Flux, Carbon storage, Water Use Efficiency, Infrared Gas Analyzer (IRGA)

GT 11 - 529 - O

CONSTRUCTED TECHNOSOLS ENHANCE BARLEY GROWTH AND REDUCE METAL UPTAKE IN POLLUTED SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Remediating mining-degraded soils is essential to restore ecosystem function and enable productive use. This study assessed six constructed Technosols for supporting barley (Hordeum vulgare L.) growth, a crop suitable for phytomanagement. Technosols (T1-T6) combined 60% soil affected by the Aznalcóllar mine spill (Spain) - still polluted 25 years later with acidic pH, low organic matter, and high levels of potentially toxic elements (PTEs) - with various non-hazardous wastes. Three organic wastes (18%) were used: composted olive-mill by-product (T1, T4), composted sewage sludge (T2, T5), and vermicompost from gardening waste (T3, T6). Additionally, 20% carbonate-rich waste from a peat bog was added to T1-T3, and 20% marble sludge to T4-T6. All Technosols incorporated 2% iron oxide-rich sludge.

Two controls were included: polluted soil (PS) and recovered soil (RS) from the latter after previous remediation. For each treatment, three replicates (pots with 2:1 soil–perlite mix) were prepared, sown with five pre-germinated barley seeds, and grown for four weeks under controlled conditions (20 °C, 80% humidity, 12 h light/dark, 60% water-holding capacity). Plant survival, shoot/root length, dry biomass, chlorophyll content (SPAD), and PTEs concentrations (ICP-MS) were measured.

Barley showed 100% survival across all treatments, confirming its resilience. However, plants in PS showed severe growth inhibition (shoot length: 9.7 cm; shoot biomass: 0.04 g; SPAD: 5). In contrast, Technosols significantly enhanced growth (shoot length: 25–39 cm; shoot biomass: up to 0.81 g; SPAD: > 40). The best performance was observed in Technosols with composted sewage sludge (T2 and T5) and gardening vermicompost (T3 and T6), highlighting their high capacity to alleviate PTEs toxicity.

PTEs analysis revealed that Technosols reduced their bioavailability, with shoot concentrations of Cu, Zn, As, Pb, and Cd significantly lower than in PS. Roots accumulated higher PTEs levels, indicating effective phytostabilization. Notably, T6 roots showed the highest As, Pb, and Cd accumulation, suggesting greater stabilization in this treatment.

Overall, Technosols mitigated metal toxicity after 25 years, partially restoring soil functionality and enabling barley growth. These results support Technosols and barley as a sustainable phytomanagement strategy for mining-impacted soils while valorizing wastes within a circular economy framework.

ACKNOWLEDGEMENTS

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GT 11 - 544 - O

DO CONSERVATION AGRICULTURE PRACTICES IMPROVE SOIL QUALITY AND CROP PRODUCTIVITY? APPLICATION TO COTTON-MAIZE SYSTEMS IN NORTHERN BENIN.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Unsustainable agricultural practices and climate change favor soil degradation, low yields, and food insecurity in Sub-Saharan Africa. In this context, conservation agriculture (CA) with soil-improving plants offers a path to more sustainable food systems. The objective of this study was to assess the effect of seven years of CA-based cotton-maize cropping systems on soil quality and crop productivity at the Okpara experimental station in Northern Benin. The trial used a randomized block design with three replications and three treatments: (S1) a two-year cotton-maize rotation with conventional tillage, (S2) a two-year cotton–maize+cowpea rotation with strip tillage, and (S3) a three-year cotton–maize+stylosanthes+crotalaria–sorghum+glycine rotation with strip tillage. Composite soil samples (0-20cm depth) were collected at the beginning of the 2024 cropping season in the row and in between rows to measure pH, total organic carbon (Ctot), total nitrogen (Ntot), permanganate oxidizable carbon (POXC), cation exchange capacity (CEC), and available phosphorus (P). Soil structural stability (0-5 cm) was measured on undisturbed 100 cm³ soil samples using the QuantiSlake Test. Soil penetration resistance (SPR) was measured at 0-10 and 10-20 cm depths with a hand-held mini penetrometer. Saturated hydraulic conductivity (0-5 cm) was assessed with a variable head permeameter (Meter group). Cotton and maize yields were recorded annually from 2017 to 2023. In cotton plots, no significant effect of cropping system or sampling zone were observed on pH, Ctot, Ntot, POXC, CEC, or P ($p>0.05$). The C/N ratio was significantly affected by sampling zone ($p<0.05$), with higher values in between rows (14.4) compared to in the row (13.0), while SPR was significantly affected by the cropping system and depth ($p<0.001$), with significantly higher values observed in S3 (3.78 kg/cm²) than in S1 (3.18 kg/cm²), and at 10-20 cm depth (3.85 kg/cm²) compared to 0-10 cm depth (2.98 kg/cm²). Infiltration rate varied by cropping system ($p<0.05$), with significantly higher values in S2 (59 mm/h) than S3 (11 mm/h). Cotton seed yield was significantly affected by year and cropping system ($p<0.001$), with 21% higher yield in S1 (1682 kg/ha) compared to S2 (1391 kg/ha). Yields in S3 were intermediate (1503 kg/ha). After 7 years, on maize plots, cropping system had a significant effect on pH, Ctot, Ntot, POXC and CEC ($p<0.05$), with higher values obtained in S1 (6.69, 0.84%, 0.063%, 260 mg/kg and 5.91 cmolc/kg, respectively) compared to S3 (6.25, 0.67%, 0.048%, 180 mg/kg and 4.66 cmolc/kg, respectively). Values in S2 were intermediate. SPR was also significantly affected by the cropping system and depth ($p<0.001$) on maize plots. No significant differences in maize grain yield were observed between the cropping system after 7 years ($p>0.05$). Overall, CA with soil-improving plants showed limited effects on soil quality and crop productivity after seven years of cropping system in Northern Benin

GT 11 - 552 - O

IN-SITU PFAS STABILIZATION BY INJECTION OF ORGANO-CLAY (INSUFIX PROJECT)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The InSuFix project, supported by Flanders/OVAM and the Knowledge Center for Innovative Remediation Solutions (KIS), is one of seven selected initiatives aimed at testing and validating innovative approaches for soil and groundwater remediation. InSuFix focuses on the use of organo-clay (OC) to immobilize PFAS contamination, both in laboratory and real field conditions.

PFAS (per- and polyfluoroalkyl substances) present unique remediation challenges due to their mobility, persistence, and complex interactions with soil and groundwater matrices. Organo-clay, with its higher adsorption capacity compared to conventional adsorbents such as activated carbon, is investigated for its ability to effectively bind PFAS compounds and reduce their mobility in the subsurface.

To assess the potential for in-situ application, the project explores the feasibility of injecting OC into the saturated zone using the patented SPIN® injection technology, developed by Injectis. His low-pressure direct injection system employs a SPIN® (spiral-shaped) injection head and adaptive pressure control to provide continuous and precise injection and ensure uniform distribution of reagents without inducing fracturing, even in low-permeability formations. The system is engineered to adjust injection parameters in real time based on subsurface hydraulic conductivity, enabling targeted delivery and effective contact with contaminants.

The InSuFix project adopts a multidisciplinary methodology that combines laboratory-scale testing with large-scale field validation at two PFAS-contaminated sites in Flanders. Laboratory experiments focus on assessing OC's adsorption performance and long-term stability under accelerated weathering conditions. During the pilot tests, Injectis will optimize both the injection parameters and the particle size distribution of the OC in order to distribute the adsorbent as homogeneous as possible in the treatment area of the two sites characterized by a different hydrogeology and PFAS signatures.

This integrated approach allows for comprehensive evaluation of the technology's strengths and limitations. The results will be compared with other available remediation strategies to support the development of optimized, site-specific remediation plans.

By fostering collaboration between research institutes, technology providers, and authorities, InSuFix contributes to the advancement of sustainable and efficient remediation practices for PFAS-contaminated environments.





GT 11 - 572 - O

TARGETING AGRICULTURAL SOIL RECOVERY THROUGH LONG-TERM COVER CROPS IN MEDITERRANEAN WOODY CROPS: IMPACTS ON ORGANIC MATTER AND WATER AVAILABILITY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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This study investigated soil properties and responses to cover cropping across 30 semiarid sites in Spain, comprising 15 paired plots of woody crops—vineyards and olive groves. Each pair included one site under cover cropping (CC) and another under conventional tillage (TILL). The duration of CC ranged from short-term (2 years) to long-term (>20 years), offering a unique chronosequence of management. All sites were located in regions with less than 500 mm annual rainfall and high evapotranspiration, highlighting the climatic constraints on soil moisture retention and fertility. Soils varied widely in texture, pH, structure, and inherent fertility, adding complexity to the interpretation of management effects.

Unlike controlled trials, this research was conducted on real farms with diverse CC species, variable management histories, and heterogeneous soil conditions—mirroring the challenges that farmers actually face. Because management categories were not always consistent—TILL plots sometimes hosted vegetation and CC plots were occasionally tilled—classification based solely on labels proved unreliable. To address this, we developed Vegetation Legacy Groups, based on cumulative above- and belowground biomass over time, to better reflect the functional history of sites.

Canonical Correlation Analysis (CCA) was used to assess multivariate relationships between soil indicators—soil organic matter (SOM), available water (AW), porosity, mineral N, and extractable P—and vegetation legacy, quantified through aboveground biomass, root biomass, and time. The CCA revealed a moderate but significant relationship between vegetation inputs and soil condition, especially in sandy soils where biomass contributions were more strongly linked to improvements.

The three Vegetation Legacy Groups, defined by quantiles of cumulative biomass, revealed clear trends. Group 3, with the longest CC history (averaging 13.6 years) and the highest above- and belowground biomass, showed the most pronounced improvements: SOM and AW content increased significantly, particularly in sandy soils. However, Group 3 also exhibited lower levels of mineral N and P, suggesting the need for adaptive nutrient management as SOM accumulates.

Spearman correlations further confirmed a significant relationship between SOM and AW only in Group 3 ($\rho = 0.29$, $p < 0.05$), reinforcing the idea that CC benefits on hydrological function require long-term commitment. These findings highlight the importance of economic and institutional support to allow farmers the time, flexibility, and resources necessary to realize the full benefits of CC in resource-constrained, semiarid perennial systems.

ACKNOWLEDGEMENTS

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GT 11 - 573 - O

SUSTAINABLE REMEDIATION OF DREDGED SEDIMENTS WITH ENERGY CROPS TARGETING ORGANIC CONTAMINANTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Over the past few decades, phytoremediation has emerged as a promising green technology for managing contaminated environments. While many studies highlight the potential of plants to remediate pollutants, most are limited to lab or greenhouse conditions, with few confirmed in the field. Field-scale validation is essential to evaluate the practical feasibility and performance of phytoremediation strategies in authentic environmental contexts. In Europe, an estimated 200 million m³ of sediment is dredged annually, often contaminated with heavy metals and organic pollutants. Despite their contamination, these sediments are rich in organic matter and nutrients, making them potentially valuable for agricultural use, provided appropriate remediation is conducted. Phytoremediation offers a sustainable and cost-effective solution for the management and revitalization of contaminated dredged sediments. By integrating energy crops with plant-microbe interactions, it is possible to remediate polluted sites while simultaneously producing valuable biomass. This study focuses on the phytoremediation of contaminated dredged sediment from a landfill located along the Begej Canal near the Serbian–Romanian border. The sediment, dredged in 2021 and deposited across a 2000 m² area, is classified as loam to silty clay, slightly alkaline, and rich in organic matter (8.37 ± 0.44%) and nutrients (N: 2360 ± 633 mg/kg, P: 390 ± 61 mg/kg, K: 132 ± 12.8 mg/kg). However, it also contains significant levels of organic pollutants: total petroleum hydrocarbons (TPH 2500 ± 750 mg/kg) and Polycyclic aromatic hydrocarbons (PAHs 1000 ± 400 µg/kg), and heavy metals (such as Cr, Cu, Pb, Zn, Cd) which are not the focus of this paper. To optimize phytoremediation approaches, a series of pot experiments were conducted with selected energy crops, including Brassica napus, Sorghum sp., white mustard, sunflower, and hemp. Based on biomass yield and contaminant removal efficiency, a rotation of Brassica napus and Sorghum sp. was selected for pilot-scale trials. Over two growing seasons, TPH were reduced by 31% after the first season and by an additional 30% after the second, achieving an overall reduction of 61%. The bioavailable TPH fraction also decreased markedly, from an initial range of 432–830 mg/kg to 19–485 mg/kg after the first season, and down to a maximum of 95 mg/kg after the second. Although no significant change was observed in total PAH concentrations, the bioavailable PAH fraction declined by approximately 50%, indicating reduced environmental risk. These results demonstrate the feasibility of using energy crops for in situ phytoremediation of dredged sediments, offering a dual benefit of pollution reduction and biomass production.

ACKNOWLEDGEMENTS

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GT 11 - 602 - O

RISK-BASED DESIGN OF BIOREMEDIATION IN HYDROCARBON CONTAMINATED SITES TO DELIVER RESILIENT SOILS: BIOAVAILABILITY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Nature-based solutions (NBS), such as bioremediation and phytoremediation, offer promising avenues for soil restoration. Traditional NBS approaches focused solely on total pollutant removals have proven unpredictable and often fall short of legislative remediation goals. With a focus on hydrocarbons, this overview presentation will explore the paradigm shift towards addressing bioavailability, surpassing mere total pollutant removals, to reach acceptable risk reductions. To achieve this, two questions must be addressed:

(1) How to influence bioavailability processes related to the biodegradation of contaminants? Contaminants that are not bioavailable to degrading microorganisms can be bioavailable to humans and ecological targets. It is therefore necessary to bring forward microbial activity to acceptable levels of risk reductions. The specific focus in our research was to unveil low-risk strategies such as the controlled increase in bioavailability to microrganisms targeting slow-desorption pollutant fractions with (bio)surfactants [1], fine-tuning the deposition and motility of microbial degraders [2], co-mobilizing non-motile inoculants [3], and effectively capturing pollutants through plant/biochar arrangements [4], showcasing their potential to transform soil remediation practices.

(2) How can this knowledge be used to sustainably reduce chemical risks in soil? In the bioremediation context, operating on bioavailability requires the use of standardized methods that can systematically be used to measure bioavailable fractions, evaluating more realistically remediation operations and end-points, in addition to assessments based on total concentrations only. Over the last 30 years, significant progress has been achieved in clarifying bioavailability concepts and methods, providing standardized options for practical application [5]. These concepts are the basis for different methodologies, ready to be used: desorption extraction, passive sampling, and biological tests. Desorption extraction is especially useful in bioremediation and constitutes the basis for an ISO standard on soil quality [6]. Our group has already used this approach in the evaluation of bioavailability-oriented bioremediation [1], proposing application paths in the context of sustainable recovery of soils contaminated by military activity [7].

ACKNOWLEDGEMENTS

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GT 11 - 616 - O

SOIL MULTIFUNCTIONALITY ACROSS VEGETATION STRATA IN TECHNICALLY RESTORED AND SPONTANEOUSLY COLONIZED METALLIFEROUS MINE TAILINGS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Metalliferous mine wastes from ore processing are among the most hazardous residues (e.g., high salinity, low nutrient and organic matter content, poor edaphic structure, high levels of metals/metalloids). These wastes were often deposited in open-air piles (mine tailings). While technical restoration commonly involves capping and afforestation, spontaneous plant colonization may occur over time when waste conditions are not too extreme. This natural process, which implies the direct growth of plants on mine wastes, offers a potential nature-based restoration alternative. Previous studies have shown signs of soil functionality in spontaneously colonized tailings. However, it remains unclear whether different vegetation strata promote distinct levels of soil functionality in technically restored and spontaneously colonized tailings. This work assessed the influence of shrubs and trees on soil functionality in both types of metalliferous mine tailings in a Mediterranean semiarid region of southeastern Spain, using a multifunctionality index approach.

Two mine tailings were selected in the former metal mining district of La Unión-Sierra de Cartagena: one technically restored (R) and one abandoned and spontaneously colonized (C). Both sites were restored or abandoned ~40 years ago, containing the same waste type (PbS and ZnS residues), and host plant communities of similar composition. In each tailing, two environments were studied: soils under shrubs and under pine trees (R-Shrubs vs. R-Trees; C-Shrubs vs. C-Trees). Seasonal sampling was conducted over one year, and multiple parameters related to soil functionality were measured to compute multifunctionality indices. Four variable categories were established: (i) soil processes (CO2 emission, C and N mineralization); (ii) organic matter decomposition (C, N and P cycle enzymes, dehydrogenase, phenol oxidase, peroxidase); (iii) nutrient cycling (dissolved organic C, phenols, hexoses, NH4+, NO3-, PO43-), and (iv) others (electrical conductivity, contamination degree, microbial biomass).

Results showed soil functional capacity in both tailing types, with vegetation effects varying within each site. In the restored tailing, shrubs and trees exhibited similar multifunctionality index values, with no seasonal variation (R-Shrubs ~9.9-11.3, R-Trees ~11.1-12.7). Indices were largely driven by C and N cycle enzyme activity and balanced C and N mineralization. In the colonized tailing, tree soils displayed higher multifunctionality index values than those under shrubs, also without seasonal shifts (C-Shrubs ~3.9-6.4, C-Trees ~8.2-9.9). In this case, P cycle and oxidative enzymes (phenol oxidase, peroxidase), along with N mineralization, had the greatest influence on index values.

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GT 11 - 621 - O

THE USE OF FOREST AND FOOD WASTES TO MITIGATE CU CONTAMINATION IN VINEYARD SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The use of copper-based fungicides, especially in organic viticulture, has become an environmental concern, as currently there are no alternatives to replace its use, an accumulation of Cu has been accounted in soils. This may have great impacts on soil health affecting the overall ecosystem function. However, Cu effects will depend on soil's physical and chemical properties, such as pH, organic matter, and clay content as they influence its behaviour and availability in soils. Thus, it is especially important to implement measures to reduce the potential adverse effects of Cu in soils that are more susceptible to contamination, due to its physical and chemical properties. The use of forest and food wastes, such as pine bark (PB) and mussel shell (MS), have been used as a mitigation measure, as, not only they alter the behaviour of Cu in the soil but also, their use as amendments contributes to the circular economy, giving them an additional value. Therefore, different concentrations of a mixture of PB and MS were incorporated into a Cu contaminated vineyard soil to verify if the addition of this mixture decreased the toxicity towards the non-target organisms of the ecosystem. A cambisol collected in a vineyard from the Vinhos Verdes Region was contaminated with different concentrations of Cu (0, 72, 111, 172, 268 and 416 g kg-1) and left stabilizing for a month. After this period, the mixture of amendments was incorporated in the contaminated soil at 6, 12 and 24 g kg-1, being these left in the same conditions and time period as described before. Some chemical soil properties such as pH, electrical conductivity, and organic matter content, were analysed and ecotoxicological assays with terrestrial (Eisenia fetida and Medicago sativa) and aquatic organisms (Allivibrio fischeri and Lemna minor) were performed, following standard protocols. Results showed that the mixture of these organic amendments was indeed effective in decreasing Cu toxicity, thus, to further investigate the individual contributions of each amendment, the concentration of 6 g kg^{-1} was selected. Additional soil incubations with PB and MS were performed with soil spiked with Cu, at the same concentrations and following the methodology previously mentioned. Results showed that MS is a key player in modulating the toxicity of Cu, mostly due to the increase of soil pH that decreases its availability in the soil. Therefore, the use of these residues provides a sustainable and environmentally friendly method to reduce Cu contamination in vineyard soils, while ensuring the restoration of soil health and the sustainability of viticulture.

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GT 11 - 670 - O

THE REDISTRIBUTION OF PRISTINE AND AGED POLYSTYRENE MICROPLASTICS (<50 MM) IN SOIL AGGREGATE FRACTIONS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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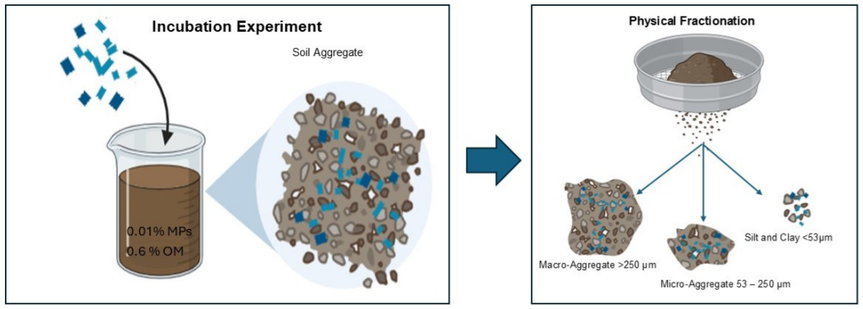
Soil aggregates play a pivotal role in soil organic carbon dynamics and microbial activity. However, their influence on the pressing issue of microplastic (MP) contamination in soils remains poorly understood. This lack of attention may be attributed to the inherent complexity and heterogeneity of soil, which renders plastic isolation and identification in soil particularly challenging. Under environmental conditions, microplastics will undergo a weathering or degradation process driven by external stressor. While aged microplastics likely behave differently from pristine microplastics due to changes in their physical and chemical properties, most conducted studies employed pristine particles. Other than that, the different sizes of microplastics will possibly affect its distribution in the soil aggregate fractions.

This study aims to investigate MPs redistribution among soil aggregate fractions during the process of soil aggregation. Two soil textures (silt loam and sandy loam) were amended with 0.01 % microplastics particles and natural organic matter (OM) to promote aggregation during a six-month incubation period. Pristine and aged Polystyrene (PS) blue colored spherical particles of different sizes (10, 25, and 48 µm) were used. After 2, 4 and 6 months of incubation, soils were destructively sampled and physically fractionated into aggregate fractions; macro-aggregates(>250 µm), micro-aggregates (53—250 µm) and within associated fractions, and silt+clay fractions (<53 µm). Organic matter was removed via oxidation to prevent interference with MP analysis. MPs were subsequently extracted from the different aggregate size fractions through density separation using Sodium Polytungstate (SPT), density 1.2 g cm-3, filtration, and examined using a Keyence VH-Z500 digital microscope. The microplastics in each aggregate fraction were then counted and converted into masses.

Addition of 0.01 % of PS did not have a significant impact on soil aggregate formation in either soil texture. After 2 months of incubation, in the main fractions (macro-aggregates, micro-aggregates, and silt+clay) MP redistribution was slightly higher in silt loam soils, with a greater proportion of MPs found in the macro- and micro-aggregates compared to sandy loam soils. Aged PS tended to redistributed in the micro-aggregate fraction. The detailed results will be presented in the conference. These findings are relevant as soil aggregates provide different levels of physical protection against degradation and mobility, influencing the bioavailability of microplastics and their potential transfer to other environmental compartments.

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GT 11 - 671 - O

PHYTOREMEDIATION OF TPH-CONTAMINATED SOIL USING HEMP AND SORGHUM

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Total Petroleum Hydrocarbon (TPH) contamination presents a long-term environmental challenge. This study evaluates the effectiveness of phytoremediation using Cannabis sativa (hemp) and Sorghum bicolor (sorghum), combined with plant growth-promoting rhizobacteria (PGPR), for remediating diesel-contaminated soil from Serbia.

A controlled pot experiment was conducted over a 10-week period, involving multiple treatment variants. Soils are previous contaminated with diesel. Then contaminated soils were either left untreated or inoculated with fungal or bacterial PGPR and then planted with hemp or sorghum. Throughout the experiment, changes in TPH concentration was quantified in the soil.

For diesel control samples (D/C), the initial TPH concentrations ranged from 67 to 280 mg/kg. Soils treated with diesel showed initial TPH concentrations, ranging from 3600 to 4420 mg/kg. After remediation, TPH levels significantly decreased to 600–3180 mg/kg, indicating strong treatment effectiveness. The percentage reduction in diesel-contaminated soils ranged from 71% to 83%. This high reduction suggests that phytoremediation with plant and microbial amendments is particularly effective in heavily contaminated soils.

These results demonstrate that the synergistic application of phytoremediation and PGPR significantly enhances the degradation of hydrocarbons in contaminated soils. Hemp and sorghum, when supported by microbial inoculants, constitute a cost-effective, ecologically sustainable strategy for the remediation of diesel-polluted environments.

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GT 11 - 679 - O

MICROPLASTICS IN SOIL AND BIOSOLID SAMPLES: QUANTITATIVE ASSESSMENT WITH A NIR SPECTROSCOPY MULTIVARIATE APPROACH

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Given the extensive research and assessment of microplastic pollution in marine environments, recent years have seen a growing shift with focus toward terrestrial ecosystems, which are now considered potentially to have greater storage of microplastic accumulation compared to aquatic systems. Industrial activities are regarded as the primary sources of microplastic pollution in soils. However, agricultural activities also contribute significantly through the use of plastic mulching films, irrigation pipes, greenhouses, compost and organic soil amendments for fertilization.

From a methodological point of view, there is currently no standardized procedure for quantifying microplastic contamination in complex matrices such as soil. Moreover, the presence of organic matter within soils further complicates the extraction of microplastics, necessitating a preliminary oxidation step. The use of spectroscopic techniques, in combination with multivariate analysis, may offer a faster and more cost-effective approach for assessing microplastic pollution.

This study evaluates the capacity of Near-Infrared (NIR) spectroscopy to quantify the presence of synthetic polymers in matrices with different organic matter contents. The presence of various concentrations of polymers, artificially added, was assessed using spectroscopic techniques coupled with multivariate analysis of spectra pre-processing and regression, starting from sandy soil samples (low in organic matter) and biosolid samples (rich in organic matter and a byproduct from wastewater treatment). Preliminary results indicate that NIR spectroscopy is capable of distinguishing different synthetic polymers from the background matrix, although variations in organic matter content influence the predictive performance of multivariate regression models. This approach could facilitate the more efficient and rapid identification and quantification of microplastics, enabling the detection of pollution hotspots and the formulation of targeted remediation strategies.

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GT 11 - 690 - O

IMPROVING THE METHODOLOGY FOR THE UNCCD SDG 15.3.1 1 LAND DEGRADATION INDICATOR BASELINE ASSESSMENT IN THE EUROPEAN UNION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Since 2018, the United Nations Convention to Combat Desertification (UNCCD) reporting process has also contributed to the monitoring of progress towards Sustainable Development Goal (SDG) Indicator 15.3.1 “proportion of land that is degraded over total land area” . This indicator is a binary quantification based on a set of three indicators also known as Strategic Objectives (SOs): (1) SO1-1. Land cover (land cover change),.(2) SO1-2. Land productivity (net primary productivity), and (3) SO1-3. Carbon stocks (soil organic carbon stocks). SO1-4, the proportion of land that is degraded land over total land, is the result of the combination of these three indicators using a One-Out-All-Out methodology and is equivalent to the SDG 15.3.1 indicator.

The European Court of Auditors special report n.33 (2018), recommended that the Commission should collate and analyse relevant data on land degradation and build on the existing indicator framework for SDG 15.3.1 so that they can be regularly presented in a clear and user-friendly way for public use in the form of interactive maps.

Therefore, we developed an updated methodology, consisting of an improvement of the baseline assessment provided by the UNCCD SDG 15.3.1 framework through a:

Improved characterization of land cover change (Schillaci et al, under review), through a more relevant nomenclature, increased spatial resolution and a revised transition matrix that assess the impact of change based on biophysical changes in vegetation cover; an optimized characterization of land productivity for the EU (Schillaci et al, under review); replacement of the changes in soil organic carbon stock indicator with a more comprehensive soil degradation indicator, representing 19 soil degradation processes (Panagos et al. 2024); application of an aridity threshold to define desertification, as highlighted in the ECA report and identification of areas vulnerable to desertification based on future scenarios for the Aridity Index.

Results based on this updated methodology show that land degradation affects all Member States of the EU, with the highest extent observed in Ireland (74.6%), Hungary, Slovenia and Spain (73%), Greece (72%), Romania and Italy (69%), Estonia (65%) and Denmark (66%).

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GT 11 - 719 - O

STRESS RESPONSE OF BRASSICA JUNCEA AND SORGHUM BICOLOR TO POTENTIALLY TOXIC ELEMENTS PRESENT IN CONTAMINATED SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Phytoremediation has proven to be an effective strategy for the reduction of potentially toxic elements (PTEs) bioavailability in soils. However, plant responses to contaminated soils may vary considerably depending on species-specific tolerance mechanisms. Understanding how different species physiologically respond to such contamination is essential for the selection of suitable candidates for phytoremediation and for the assessment of the ecological risks posed by PTEs-polluted soils.

In this study, a soil contamination gradient was established by diluting a contaminated soil with clean soil of a similar texture. The establishment of a soil contamination gradient allowed the study of different physiological stress responses of two common phytoremediation species, Brassica juncea (L.) Czern. and Sorghum bicolor (L.) Moench. Plant growth and foliar concentrations of PTEs were measured, along with physiological indicators of oxidative stress, including photosynthetic pigments, proline, and phenolic compounds, to address the potential response mechanisms to the increase in soil toxicity. The DTPA-extractable PTEs concentrations in soil mixtures were also determined and correlated to plant response parameters. Both plant species showed certain accumulation of PTEs in their leaf tissues, and significant positive correlations were found between plant PTEs concentrations and their corresponding DTPA-extractable concentrations in the soil mixtures, strongly influenced by soil-related parameters, such as pH and EC. The plants of B. juncea showed highly significant correlations between PTEs bioaccumulation and soil DTPA-extractable concentrations, and only minor changes in biomass yield and stress-related compounds concentration were shown with the increasing ratio of contaminated soil, this suggesting a high physiological tolerance threshold. In contrast, S. bicolor exhibited a pronounced physiological and biochemical response to soil PTEs concentration, with increases in chlorophyll a (23-111 %), chlorophyll b (15-85 %), phenolic compounds (22-66 %), and proline (5-84%) concentrations across the different contamination levels (20-100% of contaminated mine soil), which indicated an active adaptive response.

These findings reveal contrasting tolerance mechanisms between the species studied and highlight S. bicolor as a sensitive bioindicator for monitoring PTEs contamination in soils.

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GT 11 - 724 - O

MODERATE AND SEVERE WATER-RESTRICTION IRRIGATION STRATEGIES AND BIOCHAR APPLICATION FOR THE CONTROL OF ARSENIC AND CADMIUM IN RICE FIELDS OF THE LOWER GUADIANA RIVER, MEDITERRANEAN REGION.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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The bioaccumulation of heavy metals such as arsenic (As) and cadmium (Cd) in rice is an increasing concern due to their toxic effects on human health. This study evaluated different water management strategies and organic amendments to mitigate the accumulation of these metals in rice cultivated under Mediterranean conditions, specifically in the lower Guadiana River area (Badajoz, Spain).

Six treatments were tested by combining three irrigation regimes: Traditional (T, continuous flooding with a 10 cm water layer), Moderate (M, allowing soil water potential to reach -20 kPa), and Severe (S, reaching a water potential -70 kPa), with and without the application of holm oak biochar (TB, MB, SB). Arsenic and cadmium concentrations were measured in soil and grain, including arsenic speciation to determine its inorganic fraction (As III+V), in accordance with European Union regulations on maximum allowable arsenic content in rice for human consumption. In addition, soil chemical and biochemical properties were analyzed.

Results showed that the traditional treatment (T) exhibited the highest concentrations of total As (0.370 mg kg^{-1}) and Cd (0.009 mg kg^{-1}). The addition of biochar slightly reduced both metals in this treatment. Moderate water restriction (M) significantly reduced As (0.218 mg kg^{-1}), and its combination with biochar achieved the lowest levels of both metals (As: 0.173 mg kg^{-1}; Cd: 0.006 mg kg^{-1}). In the severe water restriction treatment (S), As concentrations were lower than the control (0.235 mg kg^{-1}), but Cd levels increased significantly (0.019 mg kg^{-1}), particularly when combined with biochar (0.036 mg kg^{-1}), suggesting a possible mobilizing effect under extreme water stress.

Inorganic As concentrations remained relatively stable across treatments (range: 0.176–0.181 mg kg^{-1}), highlighting the importance of considering not only total As but also its toxicologically relevant forms.

Furthermore, the role of dissolved organic carbon (COH) and soil pH proved critical in influencing the mobility and bioavailability of As and Cd. A positive correlation was observed between elevated DOC levels and As mobility, while biochar demonstrated a buffering capacity on soil pH, potentially contributing to reduced metal availability.

In conclusion, the combination of moderate water restriction (M) and holm oak biochar application is an effective strategy to reduce As and Cd bioaccumulation in rice. However, severe irrigation restriction, while reducing As, may substantially increase Cd uptake, particularly in the presence of biochar. Managing soil pH and COH levels should be considered essential tools in controlling the mobility of heavy metals in agricultural soils.

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GT 11 - 743 - O

FROM COMPOST TO SOIL CONTAMINATION: ASSESSING MICROPLASTICS IN FARMLAND USING ELUTRIATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The distribution in the field of composted organic wastes seems to be environmentally viable. Beside returning nutrients, trace elements, and humus to soils, it also increases soil carbon stocks, thus contributing to climate change mitigation However, most of the household and municipal solid waste composts might contain materials which can accumulate in soils, i.e. microplastics (MPs; <5 mm). Microplastics raise concerns due to their potential adverse impacts on soil health, ecosystem functions, and food safety. Agricultural soils might store more MPs than oceanic basins, so compost distribution could represent quite certain future problem: ignoring it could void the environmental benefits.

In this study, we investigated MPs in an agricultural soil in central Italy, where urban compost has been regularly applied since 2005. A device based on the elutriation principle, commonly used to process marine sediments, was adapted to extract MPs from both the whole soil (including the >2 mm skeleton fraction) and the fine earth (<2 mm). MPs were quantified and characterized by FTIR photoacoustic spectroscopy (FTIR-PAS). The bits number and total mass of recovered MPs (>34 µm) were comparable to those reported in other agricultural soils, with polystyrene, polyethylene, and polypropylene identified as the dominant polymer types.

However, the extraction process revealed critical challenges. First, sieving steps used to separate coarse material also retained lighter MPs, removing them from subsequent elutriation. Second, the presence of stable soil aggregates led to MPs being trapped within the device, underestimating their actual amount.

This work underscores the urgent need to develop and standardize protocols for sampling, extracting, and analysing MPs in soils - a matrix more complex than sediments due to its heterogeneous chemico-physical interactions.

ACKNOWLEDGEMENTS

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GT 11 - 780 - O

INTEGRATED APPROACH OF ALTERNATE WETTING AND DRYING IRRIGATION WITH BIOCHAR AMENDMENT TO REDUCE CLOMAZONE HERBICIDE WATER POLLUTION IN RICE CULTIVATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Clomazone is a widely used herbicide in rice cultivation due to its high efficacy against broadleaf weeds and grasses. However, it is also recognized as a significant contaminant of both soil and groundwater. Alternative management practices to the traditional continuously flooded system, such as intermittent flooding or organic amendment application can influence its behavior in the soil, potentially altering its environmental impact. The main objective of this work was to determine the dynamics of the herbicide clomazone in soil from the following treatments: Conventional flooding (CF), alternate wetting and drying irrigation with moderate water restriction (MWD), alternate wetting and drying irrigation with severe water restriction (SWD) and its homologues with biochar application (CFB, MWDB, SWDB). The tests were performed under laboratory conditions on field soil samples. All adsorption and desorption models showed a coefficient of determination (R2) greater than 0.95, indicating an excellent fit. Results showed that the application of biochar increased the soil absorption capacity. In addition, it was observed that the treatments with severe water restriction (SWD, SWDB) presented significantly higher adsorption capacity than the rest of the treatments. Desorption study (D) showed that the CF treatment presented significantly higher values than MWD and SWD, indicating that the permanent flood irrigation regime causes a greater mobility of the herbicide. Across all treatments, the incorporation of biochar led to a reduction in clomazone desorption by 21%, 17% and 19%, for CF and CFB, MWD and MWDB and SWD and SWDB treatments, respectively. Irrigation regime significantly influenced herbicide leaching, with lower values observed under intermittent irrigation and greater water restriction. Moreover, when comparing treatments with and without biochar, the application of this organic amendment significantly reduced clomazone leaching. Based on the results obtained, we can conclude that the integration of intermittent irrigation with biochar application effectively and sustainably reduced water and soil contamination in rice cultivation.

ACKNOWLEDGEMENTS

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GT 11 - 791 - O

LEGAL REQUIREMENTS AND REMEDIATION STATUS OF THE SITES CONTAMINATED WITH TOXIC ELEMENTS – THE EXAMPLE OF SOILS POLLUTED WITH COPPER IN POLAND

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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The communication will present legal regulations concerning the management and remediation of excessively contaminated soils in the light of EU and Polish law. The requirements of soil remediation resulting from EU soil protection strategies [1,2] and the currently processed Soil Monitoring Law directive [3] will be discussed. Practical conclusions concerning remediation required by these regulations will be discussed on the example of soils contaminated with copper, a potentially toxic element. A general review of copper sources in soils and the examples of copper-contaminated sites in Europe, documented in scientific literature, will be presented. Against this background, the Polish cases of soil contamination with copper will be characterized in more detail, with special focus on the sites affected by historical and contemporary ore mining and processing [4,5]. The Polish copper-producing concern KGHM Polska Miedź S.A. is one of the ten largest producers of this metal in the world. Its operation, especially in the last decades of the 20th century, caused strong soil contamination with copper and accompanying elements, mainly lead and arsenic. Their high concentrations in soils remain to this day, posing a potential environmental threat. Various available strategies for remediation of such soils will be discussed and the effects of remediation performed in the surroundings of Polish copper smelters will be presented. Phytostabilization strategy was applied in these areas, based mainly on soil liming and afforestation. Less contaminated soils are still used for agriculture. Basically, the applied strategy of remediation brought the expected beneficial effects, consisting in radical limiting the mobility and solubility of copper and other metals in soils and reducing related phyto- and ecotoxicity. However, this solution requires constant monitoring of soil and groundwater properties to avoid possible remobilization of pollutants and a renewed increase in environmental risk. Potential factors and conditions of such remobilization as well as the rules of controlling and limiting this effect, will be presented in the light of research made so far on these processes. Additionally, some failures in phytostabilization will be presented and discussed. The discussion will also cover the adequacy of legal regulations to potential environmental hazards.

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GT 11 - 803 - O

PERFORMANCE OF ESA-CCI-SM SATELLITE PRODUCT FOR ESTIMATING SOIL WATER DEFICIT: A CASE STUDY IN NE PORTUGAL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The Mediterranean climate is characterised by hot and dry summers and water deficit in soils. Monitoring soil water deficit is of crucial importance in Mediterranean cropland, allowing a more cost-effective soil and water management. Satellite-borne data sources provide high temporal resolution information but usually lack the spatial resolution to adequately account for soil variability, namely on the physical-chemical properties that affect soil water storage capacity. As a case study located in Bragança, NE Portugal, the present work aimed at exploring the use of ESA-CCI-SM satellite product to estimate water deficit for a wide range of soil water storage capacities. A satellite-borne soil moisture data series (ESA-CCI-SM product) was clipped for Bragança area (25 x 25 km pixel). Temperature and precipitation (P) records of a weather station located in Bragança were used to compute monthly reference evapotranspiration (ET0, Thornthwaite) and the soil water balance (SWB, Thornthwaite-Mather) along the same period (2003-2016, 168 months). SWB were computed for soil water storages (Smax) representing the Smax range of regional soils (25, 50, 75, 100, 150 mm). Following earlier work by the authors, monthly soil water deficit series (SWD), obtained for the 5 Smax, were analysed and compared with the SM monthly averages series, using basic statistical methods. Average annual P and ET0 in the study period were 750 and 711 mm, respectively. In all years, SWD occurred from June to September, with peaks in July and August (ca. 110 mm each), but it was also recorded in February and in November (1 out of 14 years). Annual SWD decreased linearly with Smax increase (R^2=0.994), from 400 mm (Smax 25 mm) to 290 mm (Smax 150 mm). The number of SWD months also decreased in the same range of Smax, from 77 to 74 out of 168. Linear regression models relating SWD to SM monthly data for each Smax were derived and applied to estimate SWD in dry months. Model performance declined with Smax increase, from Smax 25 mm (R2=0.928) to Smax 150 mm (R2=0.873), while SEE remained similar along the Smax range (23 mm). Model parameters are well correlated (R2>0.95) with Smax, allowing the integration in a single model the two variables (SM and Smax). Dry months (SWD>0) were discriminated from non-dry (SWD=0) by SM, respectively lower or higher than 0.21 m3 m-3, with 91% (Smax 25 mm) to 94% (Smax 150 mm) matching frequency. Median SM in the whole Smax range was 0.14 and 0.25 m3 m-3, for dry and non-dry months, respectively. Performance reached encourages the application of the regression models derived for estimating SWD from SM, still with a considerable uncertainty due to the high SEE obtained. As the range of Smax tested was quite large, the regression models can be applied to deliver remote-based estimates of SWD accounting for the variability of soil water storage capacities found in NE Portugal.

ACKNOWLEDGEMENTS

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GT 11 - 810 - O

INTEGRATION OF DIGITAL SOIL AND CROP HEALTH MONITORING SYSTEM: A COMBINED APPROACH FROM THE WHEATWATCHER PROJECT – A CASE STUDY OF SILESIA REGION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The growing problems of climate change together with soil degradation and decreasing crop health require integrated scalable solutions for sustainable agriculture. The WHEATWATCHER Project fulfils this requirement through its development of a complete digital system for monitoring soil and crop health which focuses on wheat-based agroecosystems across various European testing sites. The project integrates ground-based soil sensors measuring soil nutrition, chemical, and biological factors, diverse sensor technologies, advanced machine learning models, and automated mapping techniques to enable simultaneous crop and soil health evaluations. One of the WHEATWATCHER task is to Monitor heavy metals and hydrocarbons contamination in the pilot area in Silesia, Poland. The aim of our studies will be a primarily recognition of the trace element content in the Silesia region.

To achieve this, we used DSM approach. We selected 73 30-m environmental covariates and the database of 1894 points with the values of Cd, Cu, Ni, Pb, and Zn. In the modelling process we used Boruta algorithm and 15-fold cross-validation in 10 repetitions. The maps are assessed in term of model efficiency and prediction uncertainty done by cross-validation of the data used in model fitting.

The studies formerly performed in the IUNG-PIB shown that current wheat crops can be located on the potentially contaminated soils, exceeding the Polish norms (Polish Journal of Laws, 2002). The mean Cd, Cu, Ni, Pb, Zn in the Silesia region were respectively 1.40, 13.90, 16.63, 58.09, 145.34, while for the wheat crops the means were respectively 1.18, 15.13, 18.35, 47.47, 119.76. Within the wheat crops, 33% may exceed the threshold of Cd, 0.5% may exceed the norm of Ni, 3.19% for Pb, and 2.66%. The analysis indicates that soils under the wheat crops may be unhealthy and be accumulated by plants. In the further tasks of the project, we aim to monitor the variation of total petroleum hydrocarbons (TPH) and heavy metal contamination, using advanced sensing, and modelling technologies. To analyse soil properties, samples will be collected automatically within selected field (>40 ha) altogether with the vary sensors, such as, bulk-density, vis-NIR, and gamma ray sensors. Within the filed we will collect over 100 samples and analyse them for pH, SOC, P, K, Ca, Na, MC, heavy metals, PAH.

We believe that the studies will significantly contribute to the automatization of the soil monitoring to evaluate their health and safety for the food production. The WHEATWATCHER project contributes to create the infrastructure for the advanced and automatic field measurements. The planned task will help farmers to act towards the management decisions leading to safety crops and safety soil.

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GT 11 - 831 - O

USE OF BIOMASS ASHES AND PAPER-MILL BIOLOGICAL SLUDGES IN THE REMEDIATION OF PYRITE MINE-CONTAMINATED SOILS: RESULTS FROM A 2-YEARS PILOT PLOT EXPERIMENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Rehabilitation of soils affected by mining activities is difficult, and conventional constructive techniques, used alone, are inefficient to improve soil quality. In-situ stabilization techniques, through the incorporation of waste-derived amendments, may contribute to increase soil fertility, correct acidity, and immobilize potentially toxic trace elements. This study aimed to evaluate the use of wastes from pulp and paper mill industry (biomass ashes and biologic sludge from wastewater treatment) to improve the quality of soils degraded by mining activities, tested in a 25-month pilot plot experiment, with soils from three mines of the Portuguese sector of the Iberian Pyrite Belt (Aljustrel, Lousal, and São Domingos). The amendments included: (i) biomass ash granules (AG); (ii) biomass ash granules and composted biologic sludge (AG+CS); and (iii) a mixture of raw biomass ash and biologic sludge (A+S), evaluating their effect on soil physicochemical properties, total and CaCl2 0.01M-extractable As, Cu, Pb, and Zn, soil enzymatic activities, and ecotoxicity, after 1-, 9-, and 25-months soil application. All soils were very acidic (pH 3.7-4.8), low in OM content (1.6-6.9 g kg-1) and essential nutrients (N, P and K), and high in some total PTEs concentrations (182-1044 mg As kg-1, 146-1340 mg Cu kg-1, 20-2675 mg Pb kg-1 and 95-413mg Zn kg-1), some surpassing the reference values for soils intended for industrial use in “environmentally sensitive zones” (pH < 5 in the topsoil). While all amendments were able to neutralize soil acidity, with a faster response from the non-stabilized materials (A+S), an effect that remained 25-months after soil application, AG alone did not allow an increase in soil OM and N content, maintaining values without significant differences, relative to the control soil, at all sampling times, while the increase in extractable P and K were also lower applying stabilized materials (AG and AG+CS). Consequently, soil enzymatic activities of dehydrogenase, and of the enzymes from the C-cycle, β-glucosidase and cellulase, increased significantly following the amendments with biologic sludges, AG+CS and A+S, especially with the raw materials, evidencing their ability to improve soil microbial activity, an effect that decreased over time, but remained higher than the control soil after 25-months. Soils’ ecotoxicity towards Eisenia fetida, observed initially, was eliminated by the amendment’s application, which also increased the early growth of Lepidium sativum and Hordeum vulgare. Amendments’ ability to lower the risk of mine-contaminated soils was also evident by the decrease of Cu, Pb, and Zn CaCl2-extractability, influenced by pH increase, while, contrarywise, As extractability increased, although remaining very low (<0.13% of total As, 25-month after amendment).

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GT 11 - 850 - O

DEGRADATION AND RESILIENCE OF SEMI-ARID GRASSLAND SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Degradation of semi-arid grasslands in sub-Saharan Africa is not well defined or understood. We cannot necessarily apply definitions or indicators of degradation developed in temperate grasslands to these ecosystems, as they are very different in their above- and below-ground characteristics and dynamics. These tend to be low productivity systems, limited by both water and nutrients, with highly variable rainfall on both seasonal and inter-annual scales. Aboveground indicators of degradation (vegetation indices) in these regions are strongly influenced by climate variability, while indicators of soil degradation for African grasslands have not been well studied. With overgrazing and drought both serious concerns in this region, understanding both the resilience of these systems and indicators of degradation are key.

Vegetation and soil properties were measured at three semi-arid grassland sites in Kenya with different grazing histories over the two years following a severe drought. This aimed to assess the short- and long-term impacts of grazing on soil properties and plant communities; resilience to drought; and relationships between plant diversity and soil properties.

Soil physical properties were affected by recent grazing activity but not influenced by long term grazing intensity. Microbial biomass carbon and soil enzyme activity were also correlated with plant biomass (i.e., recent grazing) rather than long term grazing intensity.

Plant species richness, functional diversity and community composition were influenced by grazing intensity, but in the 18 months following the resumption of grazing at the ungrazed site, there was a partial convergence between the grazed and ungrazed sites in terms of plant diversity and community composition. Grazing mediated the impact of drought on the plant community; vegetation cover and functional group diversity was significantly lower following a severe drought in grazed than ungrazed sites. However, within a year, vegetation cover had increased to > 90% at the grazed sites, relative abundance of climax plant species was significant higher relative abundance of species associated with disturbance was lower.

Our results indicate that semi-arid African grasslands are resilient to environmental stressors such as drought and moderate grazing, with soil physical and microbial properties, vegetation cover and plant community composition being quick to respond or recover. This aligns with research suggesting that these systems operate under non-equilibrium dynamics and are stable in response to stressors [1]. For semi-arid grasslands, many of the conventional indicators of degradation appear to reflect current conditions rather than long-term differences in management and condition. Further work is therefore required to identify useful indicators of degradation for semi-arid grasslands and their soils.

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GT 11 - 922 - O

INTEGRATING CHEMOINFORMATIC AND MULTIVARIATE VOLCANIC ASH-DERIVED SOILS DATA MODELLING TO EXPLORE THE CHEMICAL SPACE OF SULFONYLUREA ADSORPTION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Sulfonylureas (SU) herbicides are widely applied for their high water solubility and eQicacy, but these intrinsic properties present a substantial risk for groundwater contamination. Despite this concern, their environmental behaviour in volcanic ash-derived soils (VADS) remains limited. These soils, particularly Andisols and Ultisols, present unique physicochemical properties that influence SU mobility and leaching risks. We investigate the adsorption- desorption of 25 SU in ten VADS from Chile, integrating chemoinformatic and multivariate soil analysis to identify key soil descriptors influencing SU environmental behaviour. Batch adsorption experiments were modelled using kinetic modelling (Hyperbolic, Pseudo-Second Order (PSO), Elovich, Intraparticle Diffusion (IPD), and Two-Site Non-g (TSNE) models) and the Freundlich model. A chemical space analysis of 3,243 agrochemicals, including SU herbicides, was examined. We applied computational chemoinformatic tools: Instant JChem 25.2.1 (Chemaxon) and the Molecular Operating Environment (MOE) to assess SU structural diversity and physicochemical profiles. Topological characterization was performed using key Chemical-finger-prints (BIT_MACCS, ESshape3D, GpiDAPH3, TAD, TAT, TGD, TGT, piDAPH3, and piDAPH4) and molecular descriptors, followed by similarity assessment through Tanimoto similarity coefficient. The PCA was performed on the similarity matrix to visualize SU distribution within the agrochemicals chemical space.

Results show that Tanimoto coefficient effectively distinguishes agrochemicals based on chemical fingerprint selection yet consistently indicates substantial structural similarity among SU and other herbicides, likely reflecting comparable modes of action. Besides, PSO indicated chemisorption as the primary adsorption mechanism ($R^2 \approx 1$), while IPD and TSNE models revealed complex multi-stage diffu-sion and dual retention processes, highlighting the heterogeneity of active sites. Adsorption capacity varied considerably, with Andisols showing greater affinity. PCA of soil variables identified bulk density, C_EH_aM, C-EHT/OC ratio, cation exchange capacity, and nutrient profiles as soil key descriptors influencing SU sorption on VADS.

The findings underscore the need to contextualize the properties of SU-VADS systems, which involved identifying relevant SU molecu-lar and VADS descriptors. This integrative approach is critical for developing predictive models of SU adsorption on VADS, conducting timely groundwater contamination risk assessments, and informing effective soil conservation strategies.

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GT 11 - 317 - F + P

SPINACH MAINTAINS PRODUCTIVITY UNDER SALINE IRRIGATION AND ACHIEVESLONGER ROOTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Climate change is bringing new challenges to global food production. In many regions, reduced precipitation and rising average tem-peratures are increasing irrigation demands, while the availability of freshwater for irrigation is decreasing. As a result, water available for irrigation may become increasingly saline. One adaptation strategy is the use of brackish water for irrigation, although its effects on crop development and soil conditions require further investigation.

This study presents the results of a field trial evaluating the response of spinach grown open-air in a sandy soil to varying levels of irri-gation water salinity. Three treatments were applied, each with three replicates: irrigation with water of 0, 3, and 6 dS m-1 during the first 29 days of the growth cycle, followed by 9 dS m-1 irrigation for all plots during the final 14 days (Treatments A, B, and C, respectively). The aim was to investigate whether gradual exposure to salinity triggers a priming effect - an adaptative response that enhances the plant's tolerance to higher salinity later in development.

The soil water content and salinity were monitored throughout the experiment, while shoot productivity, root depth, and root mass were measured at harvest. The HYDRUS-1D modelling software was used to model the soil water content, the electric conductivity of the soil solution, and root water uptake, in order to analyse the salinity stress and potential compensation through root adaptability. The root mean square error (RMSE) was below 0.017 for soil water content and under 1.19 for the electric conductivity of the soil solution, indicating good model performance.

The results indicated that saline irrigation had no significant impact spinach shoot productivity. However, plants irrigated with highest salinity since the beginning of the cycle (6 dS m-1) developed significantly longer and thinner roots than those in irrigated with freshwater (0 dSm-1), suggesting a morphological adaptation that may support productivity under salinity stress. Simulations using the reference salinity stress parameters for spinach resulted in a reduced root water uptake compared to the potential root water uptake across all treatments: 9.1 mm in Treatment A, 12.7 mm in Treatment B, and 19.9 mm in Treatment C.

The simulations using HYDRUS-1D show that the relative contribution of longer roots to root water uptake was relatively small: a 1,5 cm increase in root length reduced the root water uptake deficit in 0.56 mm. However, the modelling results also shows that incorporating a root adaptability factor, in root water uptake models nearly compensated the negative effects of salinity, helping to explain the ability of spinach to maintain productivity under saline irrigation conditions.

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GT 11 - 400 - F + P

FROM IMPACTED TO REUSABLE: DEFINING THE ECOLOGICAL POTENTIAL OF BIOREMEDIATED SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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Bioremediation is a sustainable, low-impact approach to managing contaminated soil. It enables the restoration of ecological functionality and the incorporation of these materials into the circular economy. However, for remediated soil to be safely reused, it is essential to develop a biological quality classification system that considers the soil's chemical and physical properties, as well as its biological responses.

This study presents an integrated approach to evaluating the quality of bioremediated soils, combining basic agronomic parameters with a structured ecotoxicological testing framework. The aim is to develop a reproducible, step-by-step methodology for classifying soil quality into six levels (Classes A to F), with each level corresponding to a set of potential applications in urban green infrastructure, landscape design and ecological restoration.

The agronomic potential was assessed using parameters such as pH, texture, total and organic carbon, nitrogen, total, organic and available phosphorus, and calcium carbonate. These parameters influence soil-dwelling organisms and support the interpretation of ecological performance.

The ecotoxicological workflow involves two phases using two standard soil indicator species: Eisenia fetida (earthworms) and Folsomia candida (springtails). Phase 1 comprises avoidance tests that evaluate the species' ability to detect and avoid unsuitable conditions. Soils are then assigned to preliminary quality classes (F, C or B) based on this. Phase 2 includes reproduction tests to assess chronic sub-lethal effects and refine the classification into the final classes (A to F), which more accurately reflect ecological functionality.

Phase 1 of this protocol has already been tested using samples collected from two sites undergoing dynamic biopile remediation. Each sample was tested in replicates, together with negative control.

Transparent glass vessels (15×8 cm) were divided by a Plexiglas sheet into two compartments: one containing the soil sample and the other containing sieved reference LUFA 2.2 soil (both to 2 mm). In the controls, both halves contained LUFA 2.2 soil. After removing the divider, organisms were placed in the center and exposed to a 16:8 light: dark cycle.

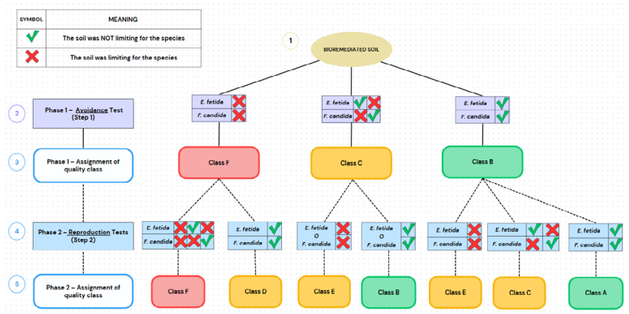
Results were expressed as Net Response Percentage (NR%). Overall, the soils that were tested exhibited a broad range of responses. While some soils showed full compatibility with both species, others indicated moderate to strong limitations, about avoidance behavior. These biological endpoints could correlate with specific chemical and physical soil characteristics. This suggests that a combined assessment provides a more reliable evaluation of the soil's ecological readiness for reuse.

The classification system supports the development of reuse strategies that align with the potential of remediated soil, thereby promoting transparency, ecological integration and sustainable land management.

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GT 11 - 42 - P

POTENTIAL OF ENERGY CROPS AND PGPR INOCULANTS FOR PHYTOREMEDIATION OF MERCURY (HG) IN SLUDGE-CONTAMINATED SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Conventional soil remediation technologies are often costly and may adversely impact soil quality. Phytoremediation using energy crops and their associated microbes presents a sustainable, cost-effective solution for soil contamination management.

A pot trial was conducted in 2024 at the Institute of Field and Vegetable Crops, Novi Sad, to evaluate the phytoremediation potential of two energy crops—wo energy crops—Cannabis sativa (hemp) and Sorghum halepense (forage sorghum), The experiment involved amending soil with sewage sludge from a wastewater treatment plant to simulate contamination. The experimental design included eight treatments, each replicated three times, resulting in 24 pots. Selected treatments incorporated Plant Growth-Promoting Rhizobacteria (PGPR) bacterial and fungal inoculants, with control treatments included for both crops. Mercury (Hg) content, identified during the initial sludge characterization, was monitored in the soil, roots, and above-ground plant parts.

Analysis revealed that hemp accumulated 2–4 times more Hg than sorghum across all treatments. Hg levels in roots were slightly higher in hemp compared to sorghum. The highest Hg concentrations in roots (47.05 µg/kg) and above-ground plant parts (7.3 µg/kg) were observed in the treatment with sewage sludge and hemp combined with PGPR/fungi. The lowest Hg levels in roots were recorded in the control treatment (13.38 µg/kg). Plant height, root mass, and above-ground biomass were measured to assess the impact of contamination. The addition of sewage sludge and PGPR treatment increased biomass and plant height, with the highest values observed in sorghum plants treated with both PGPR.

In addition to basic analyses nitrogen and carbon content were examined. The nitrogen content varied significantly between treatments. The highest nitrogen content in above-ground plant biomass was observed in hemp treatments with sludge (1.94%) and hemp with sludge and PGPR/bacterial (1.70%). Concerning carbon levels in aboveground plant biomass and roots post-harvest differences between aboveground and roots are not that pronounced. Slightly higher values are evident in aboveground biomass than in roots for the majority of the treatments.

These results provide insight into the phytoremediation potential of forage sorghum and hemp and the role of PGPR in enhancing the remediation of contaminated soils.

KEYWORDS

energy crops, sewage sludge, contaminated soils, phytoremediation.

ACKNOWLEDGEMENTS

This research was supported by the Science Fund of the Republic of Serbia, #6769, Natural based efficient solution for remediation and revitalization of contaminated locations using energy crops - ReNBES



INDEX

GT 11 - 45 - P

REMEDIATION OF PESTICIDE-POLLUTED SOIL BY PHOTO-FENTON TREATMENT AT NEUTRAL PH

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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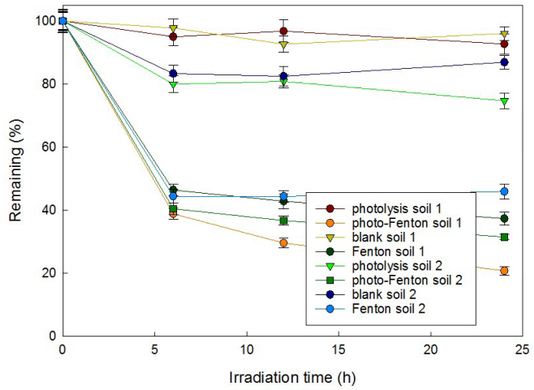
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The application of pesticides is a usual practice in modern agriculture to control pests and diseases that damage vegetables and fruit. However, a fraction of the amount used can reach the soil directly or indirectly from aerial and ground applications. These residues involve significant risk to environment and human health. It is for that reason that it is important to apply remediation technique to remove these contaminants in soil. Photo-Fenton process is an efficient technology for eliminating organic contaminants in water, but its application in soil is limited. The Fenton´s reaction [H2O2 (oxidant) + Fe2+ (catalyst)] is traditionally performed at pH 2.8. This limitation can be solved using complexes with Fe at neutral pH. Some of the preferred iron chelating agents (L) are amino polycarboxylic acids [ethylenediaminetetraacetic acid (EDTA), ethylenediamine-N,N′-disuccinic acid (EDDS), nitrilotriacetic acid (NTA)], and organic acids [oxalic acid (OA), citric acid (CA), and tartaric acid (TA). Alternatively, the catalyst used can be homogeneous Fe3+. In this work, different Fe3+ complexes with CA, EDDS and NTA were evaluated for the degradation of boscalid fungicide in two soils by photo- Fenton process at neutral pH under natural sunlight. Boscalid is a systemic, broad-spectrum fungicide that effectively controls a wide range of fungal diseases, including powdery mildew, botrytis, and alternaria in crops like vegetables and fruits. It inhibits succinate ubiquinone reductase in the mitochondrial electron transport chain.

Photo-Fenton experiments at neutral pH were conducted in spiked soils (1 mg kg−1) during August 2024. Four treatments were assayed: (i) addition of Fe3+-L and H2O2 to soils and sunlight exposure (photocatalytic treatment), (ii) addition of Fe3+-L and H2O2 to soils and dark exposure (catalytic treatment), (iii) catalyst-free soils but with sunlight exposure (photolysis treatment) and (iv) catalyst-free soils but with dark exposure (blank treatment). Soil samples were exposed to sunlight on sequential days. Once optimized (concentration of complex and hydrogen peroxide, Fe3+:ligand molar ratio, type of soil and aged spiked soil), the photo-Fenton process using sunlight was applied for reducing residual levels of boscalid in soil, showing a higher efficiency when Fe3+-citrate was used. The results showed that photo-Fenton enhanced boscalid degradation rates in comparison with Fenton, photolysis and blank (Fig. 1). Therefore, our results suggest that photo-Fenton treatment at neutral pH using Fe3+-citrate could be considered a promising technology to degrade pesticides in soil and could also be applied on a larger scale.

ACKNOWLEDGEMENTS

The authors thank the financial support received by the Project PID2022-143118OR-I00 from the Ministerio de Ciencia e Innovación. The authors are grateful to C. Colomer, H. Jiménez, J. Cava, I. Garrido, M.V. Molina and E. Molina for technical support.



Evolution of boscalid residues during the treatments assayed in both soils

GT 11 - 46 - P

PERSULFATE OXIDATION PROCESS FOR REMEDIATING BOSCALID POLLUTED SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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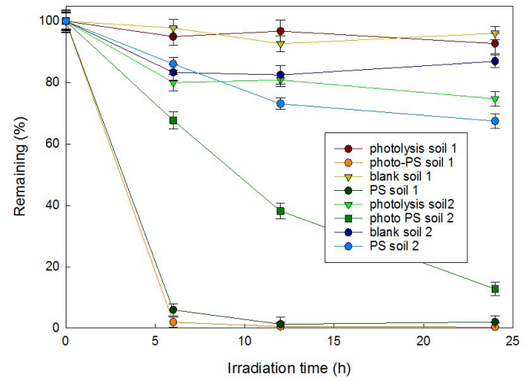
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The occurrence of pesticides in agricultural soils is an issue of increasing concern because of the risks to health of living organisms and the environment. In this context, the prevention of soil pollution and the remediation of contaminated soils should be a global priority. Soil remediation techniques for the degradation of these substances mainly involve physical, chemical, and biological processes or/and their combinations. Among them, advanced oxidation processes (AOPs) have been described as one of the best alternatives for eliminating pesticides in soil. Hydrogen peroxide (H2O2), permanganate (MnO4-), ozone (O3) and persulfate (S2O82-) are some oxidants used in soil remediation to degrade pesticides. Persulfate (PS) is a strong oxidant (E0 = 2.01 V) that can degrade most organic contaminats in soil. It has the advantages of relative stability, wider pH range, high reaction rate, high efficiency, simplicity and low cost. Usually, PS can be activated by heat, alkali, electricity, light radiation, and catalysts to generate active radicals (mainly SO4•- with a higher redox potential (E0 = 2.6 V) or •OH indirectly (E0 = 2.8 V). However, without activation, PS can also achieve considerable degradation of organic chemicals in soil. The physicochemical properties of soil and dosage of PS are the main factors affecting the application of PS in soil. The aim of this work was to evaluate, at laboratory scale under natural sunlight, the efficacy of persulfate for the degradation of boscalid (BOS) fungicide from two soils, emphasizing the influence of operating conditions, such as the initial concentration of oxidant, irradiation duration, type of soil and aged spiked soil, among others. BOS is a succinate dehydrogenase inhibitor (SDHI) fungicide that binds to the ubiquinone binding site of the SDH enzyme and blocks the TCA cycle at the succinate to fumarate reaction, leading to respiratory depression.

Oxidation experiments were conducted in spiked soils (1 mg kg−1) during August 2024. Four treatments were assayed: (i) addition of PS and H2O to soils and sunlight exposure (photo-oxidant treatment), (ii) addition of PS and H2O to soils and dark exposure (oxidant treatment), (iii) oxidant-free soils but with sunlight exposure (photolysis treatment) and (iv) oxidant-free soils but with dark exposure (blank treatment). Soil samples were exposed to sunlight on sequential days. Once the photo-PS system is optimized (concentration of PS, type of soil and aged spiked soil), the photooxidant process by using sunlight has been applied for reducing residual levels of BOS in soil. The results showed that photo-PS and PS enhanced BOS degradation rates in comparison with, photolysis and blank (Fig. 1). Therefore, the results suggested that PS could be proposed as an efficient and replicable tool for remediation purposes and could be applied on a field scale.

ACKNOWLEDGEMENTS

The authors thank the financial support received by the Project PID2022-143118OR-I00 from the Ministerio de Ciencia e Innovación. The authors are grateful to C. Colomer, H. Jiménez, J. Cava, I. Garrido, M.V. Molina and E. Molina for technical support.



Evolution of boscalid residues in soils during remediation treatments



GT 11 - 94 - P

SORPTION AND DIFFUSION OF LAMOTRIGINE IN CZECH SOILS: IMPLICATIONS FOR ENVIRONMENTAL MOBILITY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Pharmaceutical pollution in the environment is an emerging concern, particularly regarding the behaviour of active compounds in soil ecosystems. This study examines the sorption, desorption, and diffusion of lamotrigine in four distinct soil types from the Czech Republic, aiming to understand its environmental behaviour. Batch sorption experiments will be conducted to determine sorption coefficients and isotherms, while desorption assays will assess the reversibility of the process. Additionally, column experiments will be used to evaluate the vertical transport of lamotrigine under saturated conditions. By correlating sorption and transport properties with soil characteristics such as organic matter content and pH, this research seeks to provide insights into the fate of lamotrigine in terrestrial ecosystems. The findings will contribute to the broader understanding of pharmaceutical contamination in soils and its potential impact on groundwater quality.

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GT 11 - 124 - P

SOURCES OF VARIABILITY IN TRACE ELEMENT CONTENTS IN THE TOPSOIL OF THE WHITE FOREST (CENTRAL POLAND)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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The aim of this study was to identify the main sources of variability in the content of trace elements in the topsoil (0-20 cm) of the White Forest, located in the forks of the Narew and Bug rivers in central Poland. Soil samples were collected from 300 sites over an area of 1297 km2 and analyzed using standard soil science methods. Laboratory analyses included pseudo-total (aqua regia digestion) contents of Mn, Zn, Cu, Ni, Pb, V, Cr, Co, total organic carbon (TOC), pH and particle size distribution. The data obtained were processed using statistical and spatial analysis tools. Trace element contents were examined in relation to parent material origin (glacial till, glacial sand and gravel, weathered deposits, fluvioglacial sediments, kettle-hole deposits, aeolian sands, supra-flood terrace sediments, floodplain sediments), texture (texture groups, contents of texture fractions), land use type (coniferous forest, mixed forest, deciduous forest, meadow or pasture, field, wasteland) and TOC content as expected sources of variability. The concentrations of the elements studied were generally low (average 232.2 mg kg-1 Mn; 14.3 mg kg-1 Zn; 1.4 mg kg-1 Cu; 1.9 mg kg-1 Ni; 9.6 mg kg-1 Pb; 17.3 mg kg-1 V; 10.7 mg kg-1 Cr; 1.4 mg kg-1 Co) and mostly within the geochemical background. However, they varied considerably between sites. The origin of the parent material is considered to be an important primary source of the observed variability. Soils developed from glacial and weathered deposits were the most abundant in trace elements, whereas those derived from aeolian sands and sediments of supra-flood and flood river terraces were the poorest. This highlights the role of post-depositional transformation of glacial deposits into fluvial and aeolian processes as a factor in trace element distribution in recent glacial landscapes. Most of the elements studied were positively correlated with silt and clay content, while Pb was positively correlated with TOC. The different textures and parent material origins of the soils determine their type of use. It was therefore expected that differences in trace element contents would depend on the type of land use. Lower concentrations were typical for forest soils (especially in coniferous forests associated with sandy soils derived from aeolian and fluvioglacial sandy sediments) compared to arable or grassland soils. In addition, the spatial distribution of Pb is a record of military activity from the period of the First and Second World Wars. The former battlefields in the eastern parts of the White Forest show higher concentrations of the element in the soils compared to other areas.

ACKNOWLEDGEMENTS

The study was support by National Science Centre, Poland, project no. UMO-2021/43/B/HS3/02636



GT 11 - 133 - P

THE FATE OF ZINC AND COPPER IN ORGANIC FERTILIZER IN AGRICULTURAL SOILS IN NORTHERN JAPAN

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The Abashiri area in Hokkaido prefecture is an important agricultural area in Japan. In this area, compost made from dehydrated sewage sludge and straw (composted sewage sludge, CSS) is used to maintain the soil organic matter. Some farmers have each used a total of 30−40 Mg/ha of compost containing CSS since 1997. Municipal solid waste (MSW) compost contains higher amounts of heavy metals, such as zinc (Zn) and copper (Cu). Therefore, the local environmental risks of Cu and Zn from such organic fertilisers were studied. First, the long-term effect of CSS application in agricultural fields was monitored. Second, using pot cultivation, factors influencing Cu and Zn availability in the presence of organic fertilisers were evaluated under different scenarios of SOM content. In addition, the mobility and availability of Cu and Zn in organic fertilisers were assessed in a field cultivation and incubation study. In the field experiment, potato (Solanum tuberosum L.) was cultivated using CSS and pig manure (PM). In the incubation experiment, for typical soils (cambisols) sampled from fields and forests, chicken manure was added and then incubated for 40 days under 25ºC while maintaining the moisture content at 50% of maximum water holding capacity. Then the chemical fractions of Cu and Zn in organic fertilisers were evaluated by selective extraction using water, EDTA, and 0.1 N HCl.

As a result of long-term monitoring (2016−2021), the agricultural soils fertilised with CSS contained 40.7−145.7 mg/kg of total Zn. At the same time, the safe threshold value set for Zn by the Japanese Ministry of the Environment is 120 mg kg-1 of soil (Ministry of the Environment, Government of Japan, 1984).

In pot cultivation, both organic and chemical fertilisers increased the availability of Cu and Zn with a decrease in pH, possibly caused by nitrification. However, this decrease in pH was inhibited by higher SOM content, i.e. SOM mitigated the heavy metal risk from organic fertiliser.

As observed in pot cultivation, the applied chemical and organic fertilisers increased the soil-soluble and 0.1 N HCl-extractable Zn with increased nitrate under field conditions. The incubation study showed that the addition of chicken manure increased each of the water extractable, HCl-extractable, and EDTA-extractable fractions of Cu and Zn about 10 times higher, and the highest amount was in HCl extractable fraction. However, the increase of water extractable fractions was lower for the forest soils than the field soils, indicating that the high organic matter content of forest soils inhibited the solubilization of Cu and Zn. (This study has been partially reported in STOTEN 163, 2023)

ACKNOWLEDGEMENTS

This work was supported by the Abashiri Municipal Water Department.

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GT 11 - 164 - P

ASSESSING CARBON FRACTION ON SOILS OF REHABILITATED MINES OF DIFFERENT MINERALS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Mine rehabilitation is not a well-established phenomenon in South Africa, although in recently years the government has taken a strong stance to enforce rehabilitation. The unrehabilitated mines pose a problem to the environment which include loss of biodiversity, water contamination, land degradation, and socio-economic problems including illegal mining. However, there is no sufficient local based empirical data to support and give evidence that well rehabilitated soils can improve ecosystems. The aim of the research was to quantify the carbon (C) fractions under soil of different mine minerals that have been rehabilitated. The study was conducted in a semi-arid region, South Africa, where three different minerals namely chrome, diamond and manganese were mined and under each mineral there was rehabilitated, unrehabilitated and virgin soil sampled at 0-5, 5-10,10-20 and 20-30 cm depth. The results indicated that diamond under rehabilitated at 0-5 cm had highest microbial biomass C (MBC), 72.3 mg/kg, and the chrome under unrehabilitated at 20-30 cm had the lowest, -0.06 mg/kg, compared to all other treatments. The non-rehabilitated treatment under diamond at 20-30 cm had lowest concentration of Particulate Organic C (POC) of 0.06 mg/kg whereas, diamond under virgin land at 10-20 cm had the highest POC of 3.6 mg/kg. Although the distribution of C fractions is mineral dependent but, in most treatment, the non-rehabilitated indicates little amount of C which may be attributed to less biomass and subsequently significant less microbial activities. The negative concentration of MBC under chrome may be due to chrome's negative impact by causing oxidative stress to plants especially in its hexavalent form reducing biodiversity ecosystem and dysfunction. It is salient to develop concrete scientific guidelines and regulations that will enforce rehabilitation. Well rehabilitated soil will sequestrate C and consequently mitigate climate change.

ACKNOWLEDGEMENTS

The North West University, FNAS, for funding the project.



GT 11 - 188 - P

DETERMINATION OF PHYSICOCHEMICAL PROPERTIES OF BIOCHAR PRODUCED FROM DIFFERENT BIOWASTES UNDER DIFFERENT CONDITIONS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Biodegradable waste such as food scraps, garden clippings, paper, and cardboard, is also called biowaste and can be converted into biochar - a material which has gained a significant attention for its eco-friendly and sustainable properties. Biochar is highly stable both thermally and chemically, has a large surface area which can effectively capture pollutants from contaminated soil and water sources. Biochar use in soil remediation is becoming more popular due to its cost-effectiveness and environmental benefits. Additionally, producing biochar from organic waste promotes long-term environmental sustainability, because biowaste make-up around 30-40% of municipal waste in many countries, much of which still ends up in landfills, soil, or water. Recycling this waste helps reduce pollution and supports a more sustainable waste management approach.

Previous research indicates that biochar derived from biowaste can enhance soil quality, particularly in degraded soils that have lost their natural productivity and structure due to factors like erosion, pollution, and nutrient depletion. However, since biochar properties vary depending on the type of biowaste used and the pyrolysis temperature applied during production, it is essential to analyse its characteristics and identify the optimal pyrolysis conditions for the best results.

In this study, biochar was produced through pyrolysis from six different biowaste sources: hemp leaves, stems, and seed hulls, as well as sewage sludge, wood sawdust, and pig manure digestate. The process was carried out at five different temperatures (400, 500, 600, 700, and 800 °C). To evaluate the physiochemical properties of biochar, various characteristics were analysed: ash content, yield, pH, electrical conductivity nutrients and heavy metals concentrations.

The results of this study will help identify the optimal pyrolysis temperature and the most suitable biowaste source for biochar production.

ACKNOWLEDGEMENTS

The project was funded by NextGeneration EU under agreement number 10-038-T-0198.

GT 11 - 194 - P

EFFECT OF BIOCHAR APPLICATION ON HEAVY METAL SOLUBILITY AND SPECIATION IN SOILS AND SUBSTRATES AFFECTED BY METALLURGICAL ACTIVITY IN BULGARIA

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The effect of biochar (BC) on heavy metals solubility and speciation and soil properties in the vicinity of Aurubis-Pirdop Cu smelter, the former Kremikovtsi steel plant and Asarel-Medet Cu plant were studied. Maximum permissible concentrations (MPC) were exceeded for Cu (319 – 2645 mg/kg) around the Aurubis-Pirdop Cu-smelter. Lead (899 mg/kg) exceeded 2 - 15 times the MPC and arsenic, between 3 and 6 times for the soils (pH 7-8) in the area of Kremikovtsi steel plant. Incubation experiments were performed with different rates of biochar (BC), 1, 5, 10 and 20 % in a Climatic Chamber with Phytotron System. Metals were measured in water extracts and speciation was performed by Visual Minteq. For the acidic Cu-contaminated soils incubation time and BC rates led to a total decrease of Cu and Pb, while dissolved organic carbon (DOC) and pH increased with BC addition. Ion speciation in the non-treated acidic soils was represented by the free Men+ ions, while with increasing incubation time and BC rates, FA2M and M-FA gel fraction species were predominant. In the acidic soils of higher Cu contents the total soluble Cu concentration decreased by ~ 70%, while free Cu species concentrations decreased to ~ 4%. Cation exchange capacity, exchangeable Ca and pH increased from BC application, while electrical conductivity decreased, except in the Asarel waste embankments. The samples from the Asarel site include rock mass containing Cu minerals from the “Oxide Embankment” treated with sulfuric acid, and samples of rock mass from the mine overburden, “Western Embankment”. The samples are characterized by extreme acidity, pH (H2O) 3.0 - 3.9. The electrical conductivity (EC) is high and varies from 0.98 to 3.86 mS.cm-1. The RedOx potential is negative and exchangeable Al, reaches 34.7 cmol.kg-1. Cu exceeds the MPC (3-9 times) and Cd, 1.2 – 2 times. The geochemical modeling indicates predominance of free Men+ ions and Me2n+(SO4)n complexes in the untreated samples and prevalence of hydroxy and mixed complexes /FA2AlOH(aq) and /FA2Al+(aq) of Al (85%) and /FA2Cu(aq), /FACu+(aq) and /FA2CuOH(aq) for Cu. In the Asarel dump embankments free Cu2+ species and CuSO40 complexes decreased by 50% in the 20% BC ameliorated and limed substrates, while the other Men+ species were still prevailing at pH 5.9-6.4 variants. Significant correlations were obtained between plant concentrations of Cu, Mn and Zn and H2O/NH4NO3 soluble metals in the acidic soils of Aurubis-Pirdop and Medet areas, and with % OC in a multiple regression in a greenhouse experiment. Biochar incorporation has a positive effect on Cu and other metals concentrations and speciation in solution, mainly by increasing the share of less toxic and bioavailable organic species in the acidic Aurubis-Pirdop and neutral to slightly alkaline Kremikovtsi soils.

KEYWORDS

Biochar, heavy metals concentration, speciation, organic complexes, soil, mine substrates

ACKNOWLEDGEMENTS

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GT 11 - 198 - P

EFFECT OF SKID TRAIL REHABILITATION ON PHYSICAL PROPERTIES AFTER 12 YEARS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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Machine-based forestry can have severe negative effects on soil physical properties due soil compaction. In response to this degradation rehabilitation was done by excavator by creating pit- mound morphology in place of unused skid trails in Ťahanovce, Košice city (Slovakia) in 2011. Twelve years later, we evaluated the effectiveness of this rehabilitation in comparison with the natural recovery method, by assessing bulk density (0-10 cm), porosity, and soil organic carbon (SOC) (5-10 cm) on silty-loam stagnosol. Soil samples were taken from 0-5 cm depth from the surface of skid trails (SC), mounds (RS-m), pits (RS-p) and undisturbed soil (UND). Samples from 5-10 cm were taken from all mentioned categories except for mounds. We found that although physical properties of RS-p had recovered in whole studied depth, RS-m had still properties different from UND. Skid trail recovery was proved to be effective in 0-5 cm depth, but not 5-10 cm. Through the linear regression model, we found a tight connection between soil organic carbon and soil physical properties in RS-p, thus we argue that accumulation of organic matter in pits was identified as a key driver for recovery. In contrast, areas with low organic carbon content showed signs of recompaction, reflecting the ongoing challenges of soil recovery in disturbed environments. Overall, while the skid trail rehabilitation method proved effective in restoring certain soil properties over a decade, it emphasizes the need for additional measures, such as organic mulch or tree planting, to facilitate more comprehensive soil recovery and mitigate long-term compaction issues.



Rehabilitation tillage performed by an excavator is one of the methods used to mitigate soil erosion and restore soil properties after compaction on forest skid trails

GT 11 - 238 - P

INFLUENCE OF GROWING ENERGY CROPS ON HEAVY METAL CONCENTRATION AND BIOAVAILABILITY IN MULTIELEMENT CONTAMINATED SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Conventional soil remediation technologies are often costly, energy-intensive, and may negatively affect the soil quality and functions. However, natural-based solutions such as using energy crops and associated microbes may be an environmentally friendly and cost-efficient alternative. The objective of this study was to assess the influence of growing energy crops with the addition of fungal inoculants and bacterial PGPR (Plant Growth-Promoting Rhizobacteria) on heavy metal concentrations and bioavailability in multielement contaminated soil. The pot experiments with soil contaminated with Cr (137 ± 33 mg/kg), Cu (121 ± 21 mg/kg), Cd (3,43 ± 0,8), and Pb (77 ± 15 mg/kg) were performed in 2024. Forage sorghum and hemp were selected for the experiment and grown for 10 weeks in contaminated soil. Before sowing, the soil was treated with two types of PGPR: bacterial (mixture of Bacillus subtilis, Bacillus megaterium var. phosphaticum, Azotobacter chroococcum, Enterobacter, Paenibacillus polymyxa) and fungal (mycorrhizal fungi: Glomus VS, Trichoderma harzianum). Total concentration of heavy metals as well as their distribution in soil fractions were analysed before and at the end of the experiment. The BCR procedure was used to divide metals in four soil fractions: F1 – water soluble fraction, F2 – reducible fraction, F3 – oxidizable fraction, and F4 – residual fraction.

Cr, Cu, and Cd concentrations in the soil of all pots were significantly lower after the harvest compared to the start. The highest decrease in metal concentrations was noticed in pots with sorghum, where Cr concentration was decreased by 47%, Cu by 46%, Cd by 47%, and Pb by 13%. The lowest decrease in concentration was noticed in pots with sorghum + mycorrhizal fungi, and it was statistically significant only for Cu (17%). Compared to sorghum, hemp was less efficient in decreasing metal concentrations in soil (Cr was decreased by 23%, Cu by 33%, Cd by 13%, and Pb concentration remained unchanged). However, application of PGPRs significantly increased the uptake of metals by hemp, inducing a decrease of metals by 38% (Cr and cu) and 36% for Cd.

Analysis of metal distribution is soil fractions revealed that in all pots, the percentage of metals in the residual fraction (F4) was significantly lower at the end of the experiment, while the concentrations in F2 were higher than before sowing. Although Pb total concentration in soil was not significantly affected by growing hemp and sorghum, its distribution was significantly changed, and the percentage of Pb in residual (F4) fraction was significantly decreased, as presented in Figure 1.

ACKNOWLEDGEMENTS

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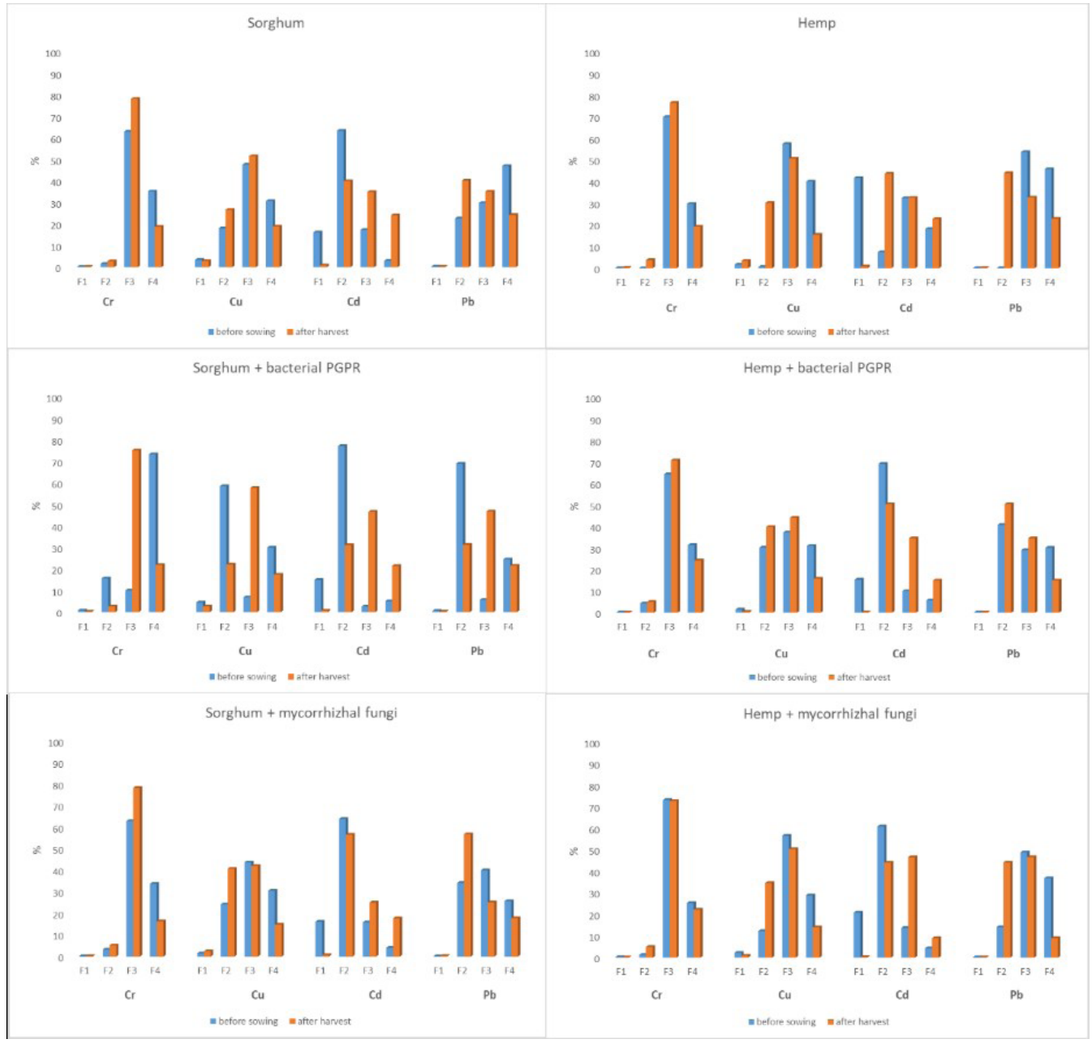


Figure 1. Metal distribution in soil fractions before sowing and after the harvest

GT 11 - 272 - P

NEW IRRIGATION PROCESS USING AQUEOUS FOAMS FOR SOIL TREATMENTS OR HEAP-LEACHING OF CRUSHED ORES.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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A new CEA/Orano patent was published in 2023 on an innovative “Method for irrigating a porous substrate using a foam, and the uses thereof” [1]. The porous substrate is a soil or a heap of ore in mining industry. This “irrigating foam process” comprises three steps (figure 1):

- preparing a foam consisting of a dispersion of air bubbles in a foaming aqueous solution, said foam comprising a liquid fraction of less than or equal to 15% by volume
- spreading, over the surface of the porous substrate, a layer of the foam thus prepared, the thickness of the layer being greater than 5 cm (10 to 30 cm)
- then maintaining the contact of the foam with the substrate long enough for at least a part of the liquid contained in the foam to infiltrate the porous substrate.

The natural gravitational drainage of the foam layer (5-30cm) deposited on the porous substrate induces homogeneous and controlled permeation flow of several liquids in the substrate porosity. The water/air foam is generated by batch or in a continuous flow rate by different specific foam generators.

In the case of soils, water for pure irrigation or water-soluble fertilizers for soil amendment were used. Various experiments were performed at laboratory scale by contacting different formulations of foam layers with different clays and sands mixtures as models of soil with low permeability. The permeation flowrate F measured is proportional to the liquid fraction ξ and the height h of the foam layer.

In majors applications for soils or ore heap leaching (uranium heap leaching), the permeation flow rate by the foam layer is measured between 5 to 25 L/(h.m²) and the foam process could replace industrial drip irrigation. Finally in the case of heap leaching of crushed uranium ore (≤ 20 mm) agglomerated with water and sulfuric acid (total moisture is around 8% w/w), different acidic foam formulations reveal very satisfactory efficiency of uranium recovery (close to 80%).

Different examples of experiments with this new irrigating foam process performed both on soil models or crushed ores will be presented and discussed during the conference.

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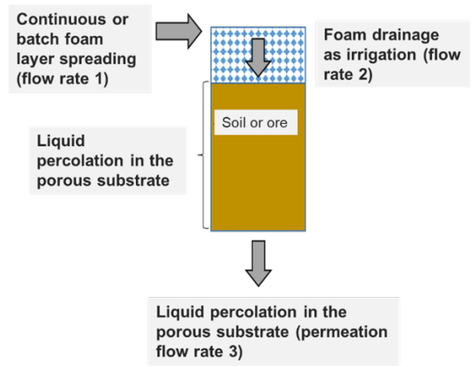


Figure 1: The irrigation foam process



GT 11 - 288 - P

LOW-COST SENSORS FOR MONITORING SOIL MOISTURE AND TEMPERATURE IN LANDSCAPE RESTORATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Soil is not consistently monitored despite its critical role in ecological function. One of the primary barriers to widespread soil monitoring is cost, which limits the ability to collect long-term, spatially distributed data. To address this gap, we deployed low-cost wireless soil moisture (AUD 60/ EUR 34.70) and temperature (AUD 5/ EUR 2.90) sensors at a site undergoing rehabilitation. The project aims to improve soil moisture retention through management interventions such as netting and wooden stakes to facilitate landscape revegetation.

Twenty-seven sensor stations were installed across an area of 2.81 km2, with each station including two soil moisture sensors installed at depths of 5 cm and 30 cm and one soil temperature sensor installed at a depth of 5cm. The soil moisture sensors have responded consistently to rainfall, drying events, and diurnal temperature and transpiration cycles over the first five months of operation. These responses aligned with event magnitude (i.e. larger rainfall events produced larger moisture changes), indicating efficacy in data monitoring from these low-cost sensors on these time scales.

The region was also progressing into drought during this time, which provides crucial data of landscape responses during hydrological extremes. On average, control sites (with higher vegetation cover) reported higher surface soil moisture (5 cm) than rehabilitated sites, likely due to natural differences in site conditions. At 30 cm depth, moisture readings were more comparable across sites. The scalded sites exhibited elevated soil moisture at both depths. This may be attributed to their proximity to a gully, where runoff accumulates or that there is no vegetation on the scald to take up the water from the soil. However, another explanation is that soil disturbance during sensor installation resulted in looser soil, temporarily increasing infiltration rates. These findings highlight the promise of low-cost sensors as scalable tools for enhancing soil monitoring in restoration contexts, particularly during periods that are subject to environmental stress (e.g. drought).

ACKNOWLEDGEMENTS

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GT 11 - 311 - P

LANDUSE CHANGES AND SCENARIO FOR MITIGATING DROUGHT RISKS IN DEGRADED LANDSCAPES (MACHINE LEARNING BASED)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Land-use changes increasingly contribute to environmental degradation and heightened hydro-meteorological disaster risks, particularly drought. This study explores drought risk dynamics by integrating remote sensing (RS) data with random forest (RF) techniques to assess drought in complex landforms. The land use scenarios consist of a Business-as-Usual (BAU) projection based on baseline conditions using cellular automata, a land capability (LC)-based scenario, and a scenario derived from participatory mapping (PM). A total of 175 field points were distributed using stratified random sampling, with 70% used for model training and 30% for validation; integrated with land use scenarios, these points were analyzed using Random Forest (RF) along with climatic, anthropogenic, topographic (landform), and vegetation index parameters. From 2017 to 2023, multistrata agroforestry declined from 21,493.54 ha to 10,809.41 ha, and natural forest cover dropped by 27.6%, while settlements more than doubled. Under the 2030 Business-as-Usual (BAU) scenario, natural forest cover may shrink to 9,195.16 ha [1]. An analysis of severe and extreme drought categories reveals a shifting drought landscape, with ‘Severe Drought’ peaking at 18.1% in 2019 before declining to 3.1% by 2030, likely due to a redistribution toward either milder or more intense conditions. Meanwhile, ‘Extreme Drought’ shows a steady increase from 6.2% to 7.0%, indicating a gradual intensification of aridity, particularly in regions experiencing deforestation [2]. The RF model achieved an overall accuracy of 92.57% [3]. Implementing the LCCPM scenario, which integrates conservation, planning, and mitigation measures, is recommended to enhance landscape resilience and support sustainable land management [4][5].

KEYWORDS

Remote sensing, land cover, machine learning, geographic information system, soil-water management

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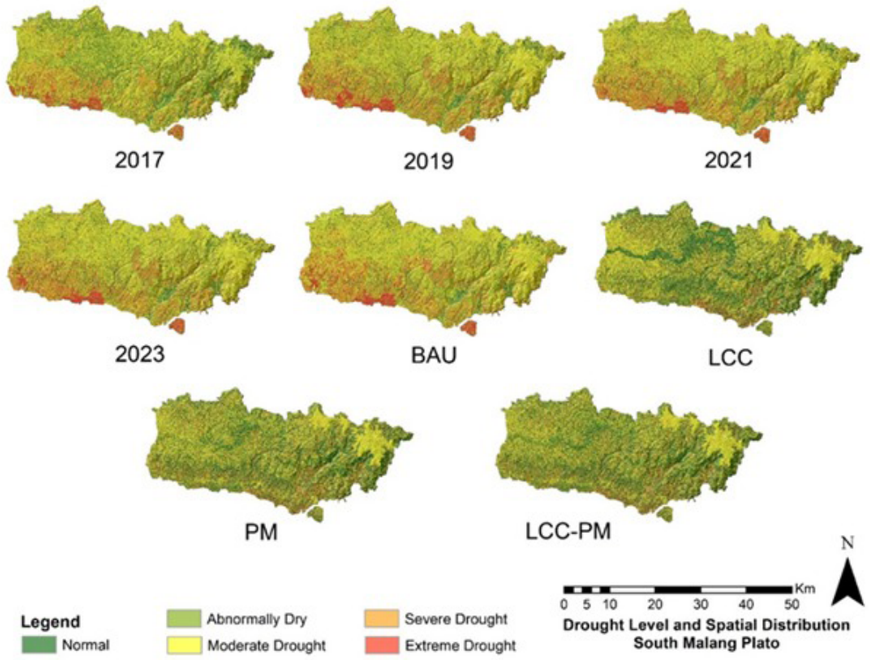
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Drought Risk Distribution of the South Malang Plateau



GT 11 - 362 - P

ADVANCED SOIL CONSERVATION FOR AFRICAN DRYLANDS: FROM EROSION MODELS TO MANAGEMENT OPTIONS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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African drylands occupied 19.6 million km2 (46% of the total global area) and 525 million people. Soil erosion models are useful for assessing the impact of soil erosion in the dryland areas. The main purpose of this research was to assess and evaluate the soil erosion/deposition models and soil conservation approaches, which are supportive for managing the impact of soil erosion in African drylands. This paper revealed that erosion models and soil conservation approaches can be used to assess and maintain soil health for food security in African dryland areas affected by soil erosion. The theories of soil erosion models and soil conservation approaches provided advanced ways to understand detail impact of soil erosion and management solutions. The combined approaches of soil conservation evaluated are also useful for enhancing dryland farming systems in Africa. The paper reported a set of useful soil erosion models and traditional conservation measures, which are supportive mechanisms for the control of soil erosion. Soil erosion models are classified as empirical, conceptual and physical that covered the Universal Soil Loss Equation (USLE) Water Erosion Prediction Project (WEPP), Chemicals, Flow and Erosion in Agricultural Management Systems (CREAMS), European Soil Erosion Model (EUROSEM), Global Assessment of Human-induced Soil Degradation (GLASOD), Water Erosion Prediction Project (WEPP), Griffith University Soil Erosion and Deposition (GUSED), and Kentucky Erosion Model (KYERMO model), Soil and Water Assessment Tool (SWAT), GIS, Remote Sensing Techniques, and Machine Learning in Google Earth Engine. Soil conservation measures include reduced tillage, advanced cover crops, mechanical structures (barriers made of stones/gravels/vegetation), advanced mechanical roller-crimper technique, mixed, intercropping, and crop rotation systems, terracing technique, and land modification techniques. Based on the study observations, these conservation measures are effective for the control of soil erosion, reduce soil damage, improve soil health and soil quality, enhance soil fertility and ensure food security. The existing assessment suggests that understanding the theories of soil erosion models and soil conservation approaches, is a first step towards addressing soil erosion problems in African drylands.

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GT 11 - 391 - P

NEW CHANCE FOR POLLUTED LANDS: RECOVERY OF AGRICULTURAL SOIL FUNCTION BY NON-FOOD FARMING AND ADAPTED SOIL MANAGEMENT AT DEGRADED SITES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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In many regions of Europe, agricultural or marginal soils are contaminated by various pollutants. Despite this, these soils are still used for growing food and feed, resulting in the uncontrolled uptake of pollutants into the food chain. The aim of the PoLaRecCE project is to develop solutions for restoring agricultural activity on contaminated and marginal lands degraded by historical human activities. Here, we present strategies for the restoration of degraded soils for non-food agricultural production, developed for four pilot sites located in different regions of Central Europe. This approach helps preserve the essential functions of soil while minimizing the transfer of pollutants into the food chain. Non-food agricultural production is considered a potential alternative source of income for farmers.

The first site is located in Liguria (Italy), on a Technosol developed from industrial waste. Since Liguria is known as the most flower-rich region in Italy, we proposed repurposing the degraded area for flower production. Our aim is to identify the most suitable flower species for cultivation at degraded pilot site. The region appears particularly well-suited for growing frost-sensitive flowering plants, given its favorable climatic conditions—provided that the soil properties of the degraded areas are also appropriate.

The second pilot site is located in an agricultural area in Békés County, southeastern Hungary. The land has been degraded due to long-term poor agricultural practices and is therefore not suitable for safe food crop production. The proposed direction of land development focuses on afforestation to produce biomass for energy purposes. Our solution involves selecting appropriate fast-growing tree species, which will also contribute to the partial phytoremediation of polluted soils. The resulting biomass will be used on the local energy market.

The third pilot site was established in Ormož (Slovenia), in an area affected by former clay mining. This soil has not been degraded by chemical contamination but rather by various forms of surface deformation resulting from excavation. The proposed solution for this area involves establishing a mulberry tree plantation. These trees can grow on relatively steep slopes and will serve as the basis for developing silkworm breeding and producing silk threads, which are used in the manufacture of wound dressings. Such dressings offer significantly better healing properties than those made from synthetic materials.

The fourth pilot site was established in Skawina (Poland), in an area contaminated by an aluminum plant and the power industry, with relatively high levels of fluorine and other heavy metals. Since there is a high demand for Christmas trees in Poland during the holiday season, we proposed establishing a spruce plantation for Christmas tree production. These trees could be delivered to offices, city squares, and private homes during the Christmas period.

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GT 11 - 397 - P

CROPPING SYSTEM EFFECTS ON SOIL GREENHOUSE GAS EMISSIONS IN RAINFED SEMIARID AGROECOSYSTEMS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Traditional agricultural management in the semi-arid areas of the Ebro Valley (NE Spain) is characterized by conventional tillage and long-term bare fallow, where the soil is intensively tilled. In contrast, conservation agriculture uses minimum or no-tillage practices and integrates cover crops during the fallow period. These different soil management approaches influence greenhouse gas (GHG) emissions, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Factors such as direct seeding, increased soil organic matter, improved soil conservation, or improved moisture retention associated with conservation agriculture play a key role in regulating GHG production and potentially changing emission levels. The main objective of this research was to evaluate the effect of different cropping systems based on the use of cover crops and no-tillage, to replace long-term bare tilled fallow, on soil GHG emissions. Management treatments included long-term bare fallow (BF) and two systems with cover crops, one with a vetch crop with mechanical termination (CC) and the other with spontaneous vegetation with herbicide termination (CF). Soil GHG samples were collected using the closed chamber method and measured by gas chromatography. The effect of nitrogen fertilizer application on soil GHG emissions was evaluated by analyzing how these emissions increased right after the application. Our results showed that the cumulative emissions of CO_2 and N_2O from the soil were significantly higher ($p < 0.05$) in the CC. The CO2 and N2O cumulative emissions decreased in the following order: CC > CF > BF. No significant differences were observed in soil CH_4 emissions. These preliminary results suggest that conservation agriculture practices (reduction in tillage intensity and the use of cover crops), result in greater soil emissions of CO_2 and N_2O. However, these practices could have other positive effects on other aspects of soil health.

KEYWORDS

Carbon, carbon dioxide, crops, emissions, extensive, fertilization, GHG, metane, Nitrogen, nitrous oxide, semiarid, Soil.

ACKNOWLEDGEMENTS

Proyect SintMed

GT 11 - 408 - P

REMEDIATION OF SANDY-LOAM SOIL ARTIFICIALLY CONTAMINATED WITH COPPER BY WASHING ASSISTED WITH ULTRASOUND.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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With the development of anthropological activities, the number of soils contaminated with heavy metals is constantly increasing and has become a global environmental problem. In 2018, heavy metals accounted for 35% of the contaminants identified in soil and ground-water in Europe [1].

Among physicochemical decontamination processes, the coupling of leaching and ultrasound may be an interesting alternative to achieve high extraction yield with fast kinetics, avoiding harsh operating conditions [2-3].

The aim of the study was to assess the contribution of using ultrasound at different frequencies (45 kHz and 358 kHz) in terms of kinetics (potential gain in terms of treatment time) and thermodynamics (potential gain in terms of extraction of the heavy metals considered). Three leaching agents were tested: hydrochloric acid (0.1 M) and two alternatives biosources, citric acid (0.2 M) and humic acid (4.5 g/L). After characterizing the soil in terms of structure, porosity and composition, a granulometric fractionation was carried out according to the protocol inspired by the Afnor NF X31-107 standard in order to identify in which fractions (clay, sand and loam) Cu is preferentially fixed. The influence of the washing/US treatment was then studied on the soil and its various fractions. Several matrices were used: the whole soil and 2 of its fractions (fine loam and fine sand), and a comparison was made with a model soil (vermiculite).

The results show that the application of ultrasound at 358 kHz is to be preferred, whatever the soil fraction considered, in order to guarantee a higher Cu desorption efficiency (for example, 90% after 1 hour of treatment for fine loam instead of 50% in silent mode). The percentage of extraction in fine sand did not exceed 35% for the three experimental conditions (Figure 1). PhreeqC software was used to predict Cu speciation according to pH and the leaching agent considered.

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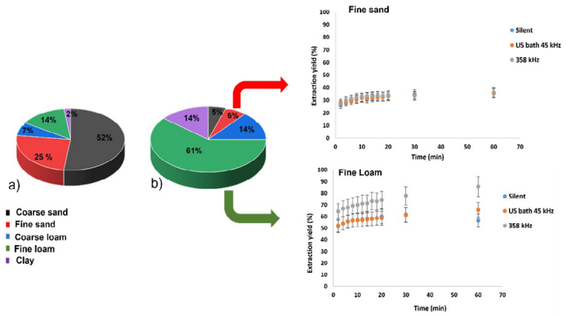


Figure 1.Circular diagram a) shows the percentage of the different soil fractions obtained following the fractionation protocol b) the distribution of Cu in each soil fraction after mineralization. Extraction of Cu in 2 soil fractions (fine sand and loam) by washing with a 0.2M citric acid solution (final pH=2.5 and solid/liquid ratio= 1/20).

GT 11 - 428 - P

NATURE-BASED SOLUTIONS FOR TRACE ELEMENT SOIL REMEDIATION USING POPLARS AND CO-CROPS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil contamination by trace elements (TE) remains a significant environmental challenge, requiring sustainable remediation strategies. The EDAPHOS project proposes a holistic and innovative land management approach aligned with the EU Mission “A Soil Deal for Europe,” aiming to reduce soil pollution and enhance restoration through Nature-Based Solutions (NBS). Agroforestry and co-cropping strategies are promising NBS options, offering the dual benefits of soil decontamination and biomass production. EDAPHOS investigates this approach across seven case studies located in France, Greece, Italy, Poland, and Spain, each presenting distinct TE concentrations, soil characteristics, and climatic conditions.

In spring 2025, field experiments were established (timing adjusted according to local climatic conditions) and will run for three years. The experimental design involves two poplar hybrids (Populus spp.) grown in combination with companion species Brassica juncea and Lablab purpureus. Treatments include monocultures of each poplar hybrid, monocultures of each companion species, and co-cropping combinations of each poplar hybrid with each companion species. A total of 32 plots (four replicates per treatment), each measuring 3.75 × 3.75 m, were established, along with one unplanted control plot for baseline comparison.

Soil samples (0–30 cm depth) were collected from each plot at the beginning of the experiment to assess baseline soil physico-chemical parameters and contamination levels. Key properties such as pH and bioavailable TE contents were measured at the beginning of the experiment and will be followed annually after each plant harvest, for a total of four sampling events. Bioavailable TE will be extracted using 0.01 M $CaCl_2$ (1:10 soil-to-solution ratio), following the method of Houba et al. (2000). Pseudototal TE concentrations will be determined at the beginning and end of the experiment via aqua regia digestion (1 HNO_3 :3 HCl).

Monitoring changes in available TE concentrations and soil properties will help assess the role of vegetation in reducing pollution. By comparing results across diverse contamination levels, soil types, and climatic conditions, this study will support the development of effective and site-specific- strategies for soil restoration and ecosystem resilience.

ACKNOWLEDGEMENTS

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GT 11 - 450 - P

INVESTIGATION OF HEAVY METAL SOIL POLLUTION OF DIFFERENT DEBRECEN SOILS IN A MODEL SOIL COLUMN EXPERIMENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Nowadays, heavy metals pollution is a notable threat to environment and human health. Due to its sustainability, toxicity and bio-accumulation, Heavy metals (HMs) have attracted extensive research attention. Unfortunately, we have little information on the soil conditions in Debrecen and its surrounding area. Therefore, in this study the soils of Debrecen, the second largest city in Hungary and the regional centre, which has been developing very dynamically in recent years were analysed in a model experiment. The study is of particular importance because of the significant industrial investments made in the city in recent years and the establishment of several new industries (automobile, battery production), which have significant land and water use and potential pollutant emissions.

The present study was conducted in the Debrecen city of Hungary to model the heavy metal (Copper and Zinc) mobility in soil with different land use types as industrial, agricultural and urban using a soil column model experiment.

The mobility of heavy metals in the vertical sections of different soils was investigated in the one month long experiment. In the pollution experiment, 100 mg/vessel, 500 mg/vessel and 1000 mg/vessel Cu and Zn doses were used by applying as Copper and Zinc Sulphate ($CuSO_4$, $ZnSO_4$) solutions and irrigated according to the typical summer period of the region.

Soil texture recorded from particle size distribution curves of studied soil types are classified according to the USDA classification. Soil saturation hydraulic conductivity (Ksat) recorded in the experiment. After the experiment the EDTA soluble Cu and Zn concentration were measured in two soil layers (0-20 cm and 20-40 cm).

According to irrigation experiments results, there was a wide range of EDTA – soluble Cu concentrations across all soil types and samples indicating varying levels of Cu contamination. The concentrations were increased dramatically from control samples to the other soil samples within each soil type according to the used pollution dose. In most cases, the upper soil layer (0-20cm) was showed significantly higher EDTA-soluble Cu concentrations compared to the deeper layer (20-40cm). When evaluating the zinc test results, similar conclusions can be drawn as in the case of copper. It can be generally stated that increasing zinc contamination doses resulted in higher zinc concentrations, especially in the upper part of the soil layer. It was also observed that the results differed among various soil types due to their different absorption capacities.

ACKNOWLEDGEMENTS

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GT 11 - 451 - P

TRANSPORT MODELLING OF INORGANIC AGROCHEMICALS IN SANDY SOILS USING HYDRUS-2D

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Agrochemicals such as fertilisers and copper-based fungicides are widely used worldwide in order to increase crop yield, protect crops, and improve soil and plant health. The excessive or irresponsible use of these chemicals could lead to accumulation in the soil posing significant environmental and health risks. Transport modelling is an excellent tool to predict environmental concentrations for risk assessment that could overall help to plan more efficient remediation technologies. Nowadays, transport models are capable to simulate the interactions among different agrochemicals, soil and water for the investigation of their mobility.

In this study, the HYDRUS software was used for the long-term prediction of environmental concentrations of ammonium nitrate and copper in sandy soils. Three different soil profile with sandy texture were surveyed and modelled in Debrecen, Hungary classified according to their land use: agricultural, industrial, urban. Daily precipitation data was retrieved from the Hungarian Meteorological Service, covering an eight-year long period. On the top of the transport domain (1×1.5 m) atmospheric, on the bottom of the domain free drainage boundary conditions were applied, then observation nodes were assigned to different soil depths in accordance of the thickness of each soil layer. The specific quantity of the leachate applied on the soil surface was chosen to be 100 Lm-2 with 1 gL-1 of ammonium nitrate and 1 mgL-1 of copper concentration. To investigate the transport processes of the above-mentioned agrochemicals, three different scenarios were considered: 1) single contamination (once, on the first day), 2) regular contamination (once a month for a year), 3) continuous contamination (every day for a month).

The results of the modelling revealed that copper could be found in the investigated soils for a long time (1-2 years), exceeding the contamination threshold (200 µgL-1) at the very beginning of the simulation period, then showing a slow prolonged depletion from the soils. Nitrate behaves differently from mobility point of view, since the adsorption coefficient of the nitrate was set to 0 m3g-1, therefore it was assumed that nitrate is completely dissolved in the liquid phase and moves with the groundwater. Ammonium and nitrate also exceeded the contamination thresholds (0.5 mgL-1 and 50 mgL-1) in each scenario. In general, nitrate also depleted slowly from the investigated soils, being above the contamination threshold for approx. 1-4 years, depending on the scenario. Ammonium converts directly from NH4-N to NO3-N as a result of the nitrification process, following a first-order decay reaction, therefore its concentration dropped relatively quickly below the contamination threshold (3 months) in the soils.

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The research presented in the article was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF-2.3.1-21-2022-00008 project.



GT 11 - 465 - P

LINKING BEHAVIOURAL BIOASSAYS AND SOIL BIODIVERSITY AS AN INTEGRATED STRATEGY FOR ENVIRONMENTAL QUALITY ASSESSMENT

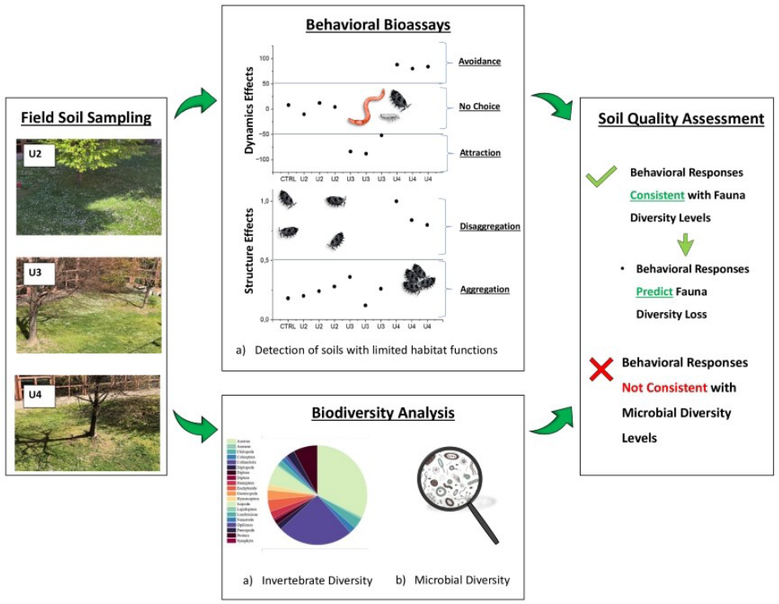
GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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Soil health is a key priority for assessing environmental safety and achieving the European Union's climate and biodiversity targets. Changes in edaphic diversity are the first indicators of soil health, but require long-term monitoring. Therefore, integrated approaches with minimal ecological and economic impact are essential. This study explores the potential of behavioural bioassays, specifically avoidance and disaggregation responses, as rapid indicators of soil habitat degradation, following the principle of limited habitat functions. Given the metrics of biodiversity loss and behavioural responses analysis are not aligned, a multi-approach comparative study was conducted to link multispecies behavioural responses with in situ measures of soil biodiversity. Behavioural tests using model organisms were employed to detect signs of habitat depopulation or fragmentation. These data were then compared with structural and functional diversity metrics of soil invertebrate and microbial communities, summarised using standard ecological indices. The results showed consistent metrics between model organisms' responses and levels of invertebrate diversity. Specifically, soils that altered population behaviour also showed a reduction in edaphic invertebrate structural and functional diversity. However, these changes did not emerge from microbial analysis, suggesting that metrics linking ecological responses of model organisms to changes in microbial diversity are yet to be investigated. This study suggests that behavioural bioassays, in combination with invertebrate diversity assessments, offer a valuable, early-warning tool for identifying soils at risk. Such integrative methodologies could support more targeted and efficient soil monitoring and restoration efforts, contributing to broader environmental protection and sustainability goals.



GT 11 - 476 - P

ENHANCED NATURE BASED SOLUTIONS FOR A FULL-SCALE REMEDIATION OF MIBK/MEK AND BTEX CONTAMINATION IN GROUNDWATER AT A CHEMICAL PRODUCTION FACILITY IN SPAIN.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The soil and groundwater of a chemical plant in operation was impacted with BTEX (mainly toluene and ethylbenzene), Methyl IsoButyl Ketone (MIBK), Methyl Ethyl Ketone (MEK, known as butanone) and TPH (mineral oil) due to past site activities. The source area of about 40 x 40 m is located underneath and in the vicinity of a tank farm. A contaminant plume of 400m x 60 m originated from this area is migrating towards a surface water body. The soil is characterized by a top layer of a mixture of gravel, sand/silt followed by silty, clayey and chalky layers with very low permeability (in the order of 10-7 m/s). The low permeability makes this a challenging aquifer where pumping wells run dry very quickly.

The groundwater presents strong reducing conditions, extreme electrical conductivity (>100,000 uS/cm) and very low Dissolved Oxygen (DO), as well as high pH values (up to pH 12). To assess the possible effects of the challenging soil conditions (high EC, reducing conditions, low permeability) on potential full scale remediation techniques, GreenSoil R&D was consulted to conduct preliminary laboratory and field tests to assess the feasibility of stimulated aerobic biodegradation and to optimize the design of the remediation.

- A biodegradation test was undertaken to investigate the degradation rate, nutrient demand, and the final concentration levels that may be achieved for MIBK/MEK.

- A biosparging pilot test was undertaken to confirm the efficiency of this NBS technique at the site.

The remedial approach implemented at the site consisted of a combination of two treatment methods based on biological solutions:

- Removal of the bulk of contamination and distribution of nutrients in the aquifer implementing a groundwater circulation system and aboveground groundwater treatment (bioreactor).

- Stimulation of the in-situ aerobic biodegradation using a biosparging system.

The groundwater circulation system consisted of the installation of 52 wells for the extraction and infiltration of groundwater.

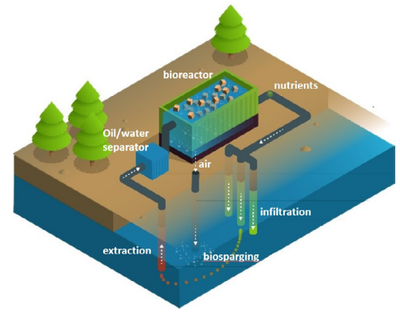
The Groundwater Treatment unit consisted of a control unit, including remote access, extraction/infiltration pumps, a bioreactor, a settlement/buffer tank, a nutrient dosage system and granular activated carbon as polishing air filtration system.

The biosparging system consisted of 44 biosparging wells both inside and outside the tank farm. These wells inject compressed air at relative low flow and pressure, to prevent stripping of the contaminants from the groundwater to the air phase, thereby creating aerobic conditions in the soil.

In conclusion, the concentration levels of MIBK/MEK as well BTEX showed a significant decrease over 2 years of operation in many areas of the site, proving that biological degradation is ongoing under aerobic conditions.

ACKNOWLEDGEMENTS

In collaboration with Ramboll Iberia





GT 11 - 490 - P

INFLUENCE OF MANAGEMENT INTENSITY OF PATAGONIAN WETLANDS MEADOWS (VEGAS) ON THEIR STRUCTURE-DEPENDENT PROPERTIES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Increasing land-use intensity alters key soil physical properties such as bulk density, water holding capacity, shrinkage, hydraulic conductivity (Ks), and structural stability. This, directly impacting the soil's ability to support ecosystem functions like water regulation, carbon storage, and vegetation growth. In the wetland meadows of southern Chile (locally called Vegas), these functions are crucial as they sustain water availability in these arid and semi-arid zones. This study aimed to evaluate soil structure-related functions in Vegas of the Magallanes Region under different management intensity

The research was conducted along a west–east precipitation gradient (600–200 mm yr^{-1}) in Southern Patagonia across four pairs of Vega sites. They were separated according to management intensity [R(low)-BB(high), PH(low)-SJ(high), VMND(low)-VMD(high), PC(high)-SC(low)]. Each pair shared similar soil types: Histosols or Gleysols (for VMND and VMD) but different management intensities (low vs. high). To determine water retention curves (WRC), shrinkage, air permeability (Ka), and Ks, undisturbed soil cores were collected from two horizons (h1: 10 cm and h2 : last depth before water table) at each site.

The WRC revealed differences in pore size-distribution and functions. BB showed greater total porosity and higher values of air capacity (AC) and plant available water (PAW) than R. In contrast, SJ-h1 and VMND-h2 had lower porosity what affect their functionality. SC-h1 exhibited a bimodal WRC with high AC but very low PAW in surface layers.

Soil shrinkage analysis showed higher contraction capacity in BB compared to R, with structural shrinkage phases present in BB-h1 and R-h2, shifting to proportional shrinkage in deeper layers. PH presented proportional shrinkage throughout, while SJ-h1 exhibited a distinct structural phase, especially within PAW-related pores. All VMND–VMD curves showed structural behavior, but VMD-h1 had higher shrinkage than VMND-h2. In PC–SC, SC-h1 displayed greater shrinkage capacity than PC-h1, which showed only a proportional phase in AC-related pores.

For soil hydraulic functions, BB had higher Ka and Ks values than R, though not statistically significant. A significant difference in Ks was observed in the PH–SJ comparison, where SJ demonstrated greater Ks. No clear trends or significant differences were found in VMND–VMD and PC–SC pairs, with variation being more pronounced between soil depths than between intensities of management.

The management intensity does not show a consistent effect on soil physical properties. In some cases, intensification improved conductivity and storage functions (e.g., BB), while in others it reduced them (e.g., SJ-h1). These findings highlight the context-dependent nature of soil functional responses and the importance of site-specific management strategies in conserving soil ecosystem services in Patagonian wetlands.

ACKNOWLEDGEMENTS

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GT 11 - 515 - P

OCCURRENCE OF MICROPOLLUTANTS IN AGRICULTURAL SOILS OF THE CZECH REPUBLIC IRRIGATED WITH RIVER WATER

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Agricultural soil can be contaminated by various micropollutants. One of the sources of these contaminants is agricultural practice, where a variety of pesticides are used for plant protection. The spectrum of the pesticide depends on the cultivated crops. Another source of contamination can be river water that is often used for irrigation. This water may contain various micropollutant including pesticides, industrial chemicals, pharmaceuticals, and personal care products. River contamination depends on the sources of the compounds, that can be, for example, discharged wastewater, surface water runoff from agricultural or urban land, etc. Therefore, contamination can vary both between individual rivers and along one river. Our study focused on soil contamination in areas irrigated with water from three rivers in the Czech Republic. Soil sampling was performed in spring and summer 2024. The plots were mainly used to grow vegetables (carrots, parsley, cauliflower, onions, celery, brussels sprouts, radish or potatoes), but also corn or soya. Targeted LC-MS2 methods were used to measure concentrations of selected pesticides, pharmaceuticals, industrial chemicals, and their metabolites. In total 54 pesticides and their metabolites were found in the entire set of soil samples. The concentrations of 10 pesticides and their metabolites were higher than 100 ng/g of dry soils. The sum of their concentrations in one soil sample varied between 43 and 5249 ng/g of dry soil. Ten pharmaceutical substances were found in the entire set of soil samples. However, a maximum of two pharmaceuticals were quantified in one soil sample. The maximal sum of their concentrations in one soil sample was 1.4 ng/g of dry soil. Other substances detected in all soil samples were benzotriazoles (max concentration of 8.9 ng/g of dry soil), which are used for example as metal corrosion inhibitors or as ultraviolet light stabilizer additives in plastics and polymers, and 1,3-diphenylguanidine (max concentration of 7.6 ng/g of dry soil), which are used in the vulcanization of rubber and other polymers (tires, building materials, furniture, etc.).

ACKNOWLEDGEMENTS

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GT 11 - 531 - P

THE POTENTIAL OF MICROPOLLUTANTS ORIGINATING FROM IRRIGATION WATER TO CONTAMINATE SOIL AND GROUNDWATER

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Agricultural soil can be contaminated by various organic micropollutants, e.g., pesticides used for plant protection and weed reduction, pharmaceuticals, personal care products and industrial chemicals that can occur in irrigation water. The accumulation of compounds in soil or their migration towards groundwater depends on many factors, i.e., climatic conditions, the properties of the vadose zone environment, sorption of compounds in soils and sediments, and their stability in the soil-water environment.

Our study first focused on the occurrence of organic micropollutants in various matrices (surface and groundwater, soils and plants) in areas intensively irrigated with river water that could be contaminated by compounds in discharged wastewater, runoff from agricultural lands, urban and industrial areas. Six compounds, which likely originated from contaminated surface water, were selected from a wide range of diverse compounds identified: 1,3-diphenylguanidine, triethyl citrate, napthalene-2-sulfonic acid, benzo(d)thiazole-2-sulfonic acid, 4-acetamidoantipyrine, and 6:2 fluorinated telomer sulfonate.

Our study further focused on the potential of the selected compounds to accumulate in soil or contaminate groundwater. To find out the influence of various soil properties on their sorption in soil, standard sorption experiments were performed for each of the compounds and 16 representative soils of the Czech Republic. Freundlich sorption isotherms were then calculated for each compound and soil, which describe the equilibrium between the concentration in solution and the concentration sorbed on soil particles. Then, correlations between the Freundlich sorption coefficient (KF) that were expressed for the average n value characteristic for each compound and soil properties were evaluated. The largest sorption was found for 1,3-diphenylguanidine followed by triethyl citrate, 4-acetamidoantipyrine, 6:2 fluorinated telomer sulfonate, benzo(d)thiazole-2-sulfonic acid, and napthalene-2-sulfonic acid. While the sorption of the first three was controlled by the cation exchange capacity or clay content, the sorption of the remaining ones correlated with the organic carbon content or potential wettability index. Multiple linear regressions were also used to derive equations for predicting KF values using the properties of tested soils. These equations and maps of soil properties were used to predict the KF value distributions within the irrigated areas and subsequently to delineate classes of compounds' mobility in the soil environment, i.e., to assess their potential leakage towards groundwater and/or accumulation of the compounds in soils and availability for plants.

ACKNOWLEDGEMENTS

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GT 11 - 540 - P

HEAVY METAL DISTRIBUTION AND CONCENTRATION INFLUENCED BY THE WATERS OF THE ATOYAC RIVER IN PUEBLA AND TLAXCALA, MEXICO.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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In the metropolitan area of Puebla and Tlaxcala, waste discharge into the Alto Balsas sub basin constitutes an environmental issue that has increased throughout recent years due to the expansion of urban settlements, causing health issues derived from consumption and irrigation water use. The article´s objective was to evaluate heavy metal contamination in soils and surface water used for agricultural production and to conduct a spatial analysis of heavy metals locating the potential sources of contamination. The study was carried out in three representative areas of the sub-basin, collecting water and soil samples to determine the concentration of heavy metals and chemical properties. The geoaccumulation index (Igeo) and enrichment factor (EF) were obtained, and the spatial distribution analysis for heavy metals was made by interpolation using the IDW method. The results showed median concentrations of Cd, Co, Cr, and Ni above the US EPA (2012) recommendations for irrigation water-use. Cr values exceed the maximum levels for agricultural soil-use. The concentration of metals through the Alto Balsas is not only reduced to industrial activity, it can also be linked to the dumping of untreated domestic and agricultural waste.

The Igeo showed strong to moderate contamination in concentrations of Cd, Co, and Zn elements, while Cr, Cu, and Ni resulted in moderate contamination, the presence of different industrial sectors is a possible cause of a high number of elements showing a certain degree of contamination, 7 of the 9 metals show Igeo greater than 1, which indicates that there is contamination as a result of various anthropogenic sources.

The EF showed significant enrichment for elements such as Cd, Co, Cr, Cu, and Zn, related to anthropogenic sources. The significant enrichment can relate to an industrial and domestic pollution in the region, due to the treated and untreated irrigation water-use.

From the spatial distribution, it is possible to identify the contamination sources of heavy metals, associating the causes with the increasing urban areas and the industrial growth in the Alto Balsas region, which, due to the lack of regulation for waste discharges contributes to the accumulation of heavy metals, generating pollution in agricultural soils. The highest concentrations of metals in the entire study area were identified and can be attributed to the continuous irrigation that has prevailed for decades. For more than 60 years, the industrial and urban areas of the region have released wastewater into the rivers of the Alto Balsas, contributing to the pollution of low-lying areas and agricultural soil.

Continuing with spatial distribution approaches will provide the guideline to generate scientific information, in order to develop prevention, control, management and remediation actions, contributing to environmental legislation on issues of regulations on heavy metal concentrations in watershed management.



GT 11 - 588 - P

POTENTIAL OF THE HERBICIDE METAZACHLOR AND ITS TWO METABOLITES ESA AND OA TO MIGRATE IN THE SOIL-WATER ENVIRONMENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Various herbicides are used to eliminate weed growth. One of the widely used compounds is metazachlor. This compound is relatively quickly transformed in the soil into various metabolites, particularly metazachlor OA and metazachlor ESA. These metabolites then show much greater stability and are often found in the water environment. To assess mobility of the parent compound and both metabolites in the soil environment and consequently their potential to contaminate groundwaters of the Czech Republic, the batch sorption experiments were performed for these three compounds and eight representative soils of the Czech Republic. The experimental sorption isotherms were fitted with Freundlich equations. The resulting Freundlich sorption coefficients (KF) expressed for average n exponent (n-avg) were related to soil properties to obtain pedotransfer rules, i.e., equations for predicting KF coefficients from soil properties. Metazachlor showed high and even very high mobility in soils. The KF values for n_avg=1.19 varied between 0.23 and 2.94 cm3/nµg1–1/ng−1. Both metabolites indicated even lower sorption, i.e., an extremely high mobility in the soil environment. The KF values varied between 0.093 and 0.28 cm3/nµg1–1/ng−1 (n_avg=1.21) for metazachlor OA and 0.083 and 0.31 cm3/nµg1–1/ng−1 (n_avg=1.13) for metazachlor ESA. Sorption of all compounds was mostly affected by the soil organic carbon content and less by other properties, e.g., pH and clay content. These pedotransfer rules and maps of soil properties of the agricultural soils of the Czech Republic were next used to predict maps of the KF coefficients and subsequently to delineate classes of compounds' mobility in the soil environment. Finaly, specific groundwater vulnerability maps for each compound were obtained by combining the DRASTIC vulnerability index, mobility index and stability index. The maps were confronted with the occurrence of these compounds in the groundwater of the Czech Republic. The maps will be further used to improve the groundwater quality monitoring network.

ACKNOWLEDGEMENTS

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GT 11 - 595 - P

NEGLECTED AND UNDERUTILISED SPECIES: AN EXCELLENT TOOL FOR INCREASING SOIL QUALITY AND INDUCING AN ECONOMIC YIELD

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The Mediterranean basin is a biodiversity hotspot with many plants adapted to drought and poor or saline soils. Traditionally used by rural communities, these species are rich in compounds with nutritional, cosmetic, and medicinal value, and offer multiple ecosystem services. Known as NUS (neglected and underutilized species), these plants demonstrate greater resilience to adverse environmental conditions compared to major crops such as cereals and vegetables. They have the potential to positively influence the soil water balance through crop residue incorporation and air humidity interception, enhance soil organic carbon (SOC) storage, and improve soil quality by supplying nutrients and reducing soil erosion.

Although NUS remain largely outside global markets, they represent a viable alternative for farmers, particularly smallholders, to generate economic value by converting marginal lands into productive areas. At the same time, they help improve environmental quality and avoid competition with water-intensive crops and other users.

The main objective of this study is to demonstrate the environmental and economic potential of introducing low water-demanding NUS, adapted to arid conditions and other limiting soil factors such as high salinity, low nutrient availability, and land degradation due to desertification. The selected species include Crithmum maritimum and Salicornia europea, which have shown strong market potential, providing a range of valuable products and achieving good yields under saline and water-limited conditions, as well as Atriplex, used to combat coastal soil erosion, as a protein source for grazing animals, and as a medicinal plant.

The pilot site is located south of the Venice lagoon in a low-lying agricultural area (up to -5 m a.s.l.), managed hydraulically through pumping stations and subject to subsidence and saltwater intrusion. Specifically, two non-productive marginal grasslands in the Zennare and Gesia areas, totaling approximately 1.8 hectares and owned by the CONSAE partner, were selected due to their contrasting characteristics: Zennare soil has higher organic matter, salinity, and acidity compared to the Gesia site. Another test site is located in Camerano (Central Italy), owed by Rinci srl, within the Conero Mountain Regional Park (elevation ~100 m a.s.l.), characterized by sloping (~10%) calcareous clay soil with a pH of 8.4 and low organic matter and nitrogen levels. This site was used to assess the performance of Crithmum maritimum, already present in the area, and to test Atriplex for the first time. Both partners are involved in the VENUS project (https://venus-project.org/).

Both chemical-physical (e.g., organic carbon, total nitrogen, pH, electrical conductivity) and biological (enzyme activity) analyses were conducted. The results confirmed that NUS species are well-suited to improve the characteristics of marginal soils while also providing tangible yields for landowners.



GT 11 - 615 - P

GEOSTATISTICAL FUSION OF FIELD AND REMOTE SENSING DATA FOR ASSESSING SOIL SALINITY IN SOUTHERN REGION OF MOROCCO

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil salinization is the process of accumulation of water-soluble salts within the upper part of soil profile (particularly A and B horizons). Salinization originates from different sources and is one of the major worldwide soil threats, which rarely comes alone. Therefore, quantifying and spatial modelling of indicators of salinization is crucial to manage and mitigate the soil salinization process. The use of remote sensing in mapping and assessing soil salinization represents the possibility of achieving ever greater spatial resolution, particularly in conditions where it is difficult or too much expensive field measurements or collecting soil samples. One of these cases is presented in this study in a southern region of Morocco. The sampling campaign was conducted in Laayoune-Sakia El Hamra and Dakhla-Oued Ed-Dahab regions in the south of Morocco. An arid climate characterizes these regions with sandy to clay soil. 600 samples were collected from these areas at depths of 0 to 20 cm. The sampling method was designed to capture maximum variability across the study areas while ensuring sample homogeneity within each sub-region. A crucial problem to be solved to use spatial data of different nature and characteristics, such as field and remote sensing data, is the support of measurement, which is very different between the types of data. Therefore, to solve this issue and derive the maximum information, it is necessary to apply appropriate techniques of spatial statistics by defining a spatial statistical model. In this study, a multivariate geostatistical approach is proposed that can fuse data of different types, including soil sample satellite data, to model and map soil electrical conductivity, considering the various supports and their impacts on prediction. Remote sensing data consists in pixels which are considered as the average reflectance of light from a limited support. Therefore, decomposing the original support into a set of finer supports was necessary to combine field and remote sensing data.

GT 11 - 623 - P

MINE TAILINGS SOILS WITH DIFFERENT VEGETATION COVER RESPOND UNEQUALLY TO FORECASTED CLIMATE CHANGE CONDITIONS: AN EXPERIMENTAL APPROACH SIMULATING ELEVATED CO2 AND TEMPERATURE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Metalliferous mine wastes from ore processing were often stored as slurries in open air piles known as mine tailings. These tailings typically present harsh conditions for biota, including high salinity, low nutrient and organic matter content, poor edaphic structure, and elevated concentrations of potentially toxic metals and metalloids. Conventional restoration strategies (technical reclamation) usually involve waste capping with clean material and afforestation. As a nature-based alternative, phytomanagement (particularly phytostabilization) supports plant growth directly on mine wastes. This approach can benefit from studying native vegetation that spontaneously colonizes tailings and underlying soils (passive restoration). Since restoration aims to reduce risks to human populations and enhance long-term environmental quality, it is crucial to assess how tailing soils, whether technically restored or spontaneously colonized by vegetation, respond to climate change.

In this work, we experimentally assessed physicochemical and biological changes in soils from technically restored and spontaneously colonized tailings under simulated climate change conditions. For each tailing type, soil samples were collected beneath shrub and pine tree vegetation in the former metal mining district of La Unión-Sierra de Cartagena (Cartagena, SE Spain). Plastic pots were filled with 850 g of each of the four soil types and placed in climate-controlled chambers for four months (two months simulating spring conditions and two simulating summer conditions). Climate simulations were based on IPCC projections for the Mediterranean basin incorporating atmospheric CO2 levels and air temperature. Three scenarios were tested: current conditions (400-500 ppm CO2, current temperature); moderate warming (700 ppm CO2, +3 °C); strong warming (1000 ppm CO2, +5 °C). A range of physicochemical and biological parameters was assessed in soils samples collected at the end of each simulated season. Soil responses varied across climate scenarios and parameters and were influenced by both tailing type and vegetation cover. The findings highlight the need to integrate climate change projections into future mine tailings restoration strategies.

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GT 11 - 663 - P

EXPLORING SOIL ENZYMATIC ACTIVITY THROUGH MULTIVARIATE ANALYSIS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soil pollution by veterinary antibiotics, as reported internationally, has shown that a significant portion of antibiotic inputs into soils originates from intensive production systems, particularly poultry and swine farms. This factor should be carefully considered when selecting soil sampling sites. Due to the need for sensitive indicators to monitor the presence of these pollutants, this study evaluates soil enzymatic activity (SEA) associated with the biogeochemical cycles of carbon (C), nitrogen (N), phosphorus (P), and sulfur (S), establishing its relationship with soil moisture, organic matter (OM), pH, electrical conductivity (EC), and bulk density (BD). The soils included in this study (n=13)—Temuco, Frutillar, Colina, Ralún, Nueva Braunau, San Fernando, Vilcún, Osorno, Santa Bárbara, Diguillín, Freire, Metrenco, and Collipulli—are located near agricultural production facilities in the south-central region of Chile. Samples were collected at a depth of 0–20 cm and sieved to a particle size of <2 mm. All soils were characterized prior to measuring SEA, including urease (QUA), dehydrogenase (QDHA), acid phosphatase (QPACID), arylsulfatase (QARY), and β-glucosidase (QGLUC), by using spectrophotometry. Multivariate statistical analyses included Principal Component Analysis (PCA), Cluster Analysis (HCA and K-means), and Partial Least Squares Regression (PLS). The results indicate that SEA follows the decreasing order QPACID > QUA > QGLUC > QARY > QDHA, with QPACID and QUA showing the highest activities, highlighting their roles in the mineralization of phosphorus and nitrogen, respectively. QGLUC contributes to the supply of carbon and energy for soil organisms, with activity linked to cropping history and the sampling season. QARY exhibited low activity, suggesting limited mineralization of organic sulfur, while QDHA showed the lowest activity, indicating low rates of aerobic microbial respiration. The PCA explained 78.25% of the total variance. PC1 (42.82%) was associated with biological fertility, emphasizing the influence of OM and moisture on QPACID and QUA, with high fertility observed in Nueva Braunau and lower fertility in Collipulli and Metrenco. PC2 (22.36%) related to pH and EC, with positive values in Santa Bárbara and Colina. PC3 (13.07%) highlighted QARY as a key variable, particularly in Nueva Braunau. Cluster analysis identified groups of soils with similar characteristics, although Nueva Braunau and Colina showed unique profiles. PLS regression produced predictive models linking soil parameters to enzymatic activity, confirming the relevance of OM and moisture.

Soil enzymatic activity is a sensitive, rapid, and cost-effective indicator for monitoring the relationship between contaminants and biogeochemical processes, offering valuable insights for sustainable land management.

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GT 11 - 692 - P

ASSESSMENT OF SEAWEED CAULERPA PROLIFERA FROM MAR MENOR LAGOON TO STABILIZE POTENTIAL TOXIC ELEMENTS IN MINE TAILING

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The Mar Menor, a coastal lagoon in southeastern Spain, has undergone profound ecological degradation due to eutrophication triggered by agricultural runoff and mining legacy. One of the most visible consequences is the proliferation of opportunistic macroalgae, notably Caulerpa prolifera, which accumulates in massive quantities on the shores. While this biomass is often treated as waste, it represents a potential biotechnological resource. This study investigates the valorization of this algal residue and its resulting compost as amendments to reduce the mobility of potentially toxic elements (PTEs) in mining wastes from the abandoned Bustarviejo silver mine (Madrid, Spain).

A one-month incubation experiment was conducted in controlled conditions. Three treatments were applied to mining debris: no amendment (control), 3% (w/w) dried algae, and 3% (w/w) composted algae. Weekly pore water sampling allowed for the monitoring of pH, electrical conductivity (EC), total organic carbon (TOC), and PTE concentrations (As, Cd, Cu, Pb, Zn). Post-incubation, the BCR sequential extraction method was used to analyze PTE partitioning among exchangeable, reducible, oxidizable, and residual fractions. Soil microbial activity was assessed through dehydrogenase and total hydrolase activities.

Results showed that both amendments increased pH and TOC compared to the control, enhancing conditions for PTE immobilization. Compost was more effective in decreasing PTE solubility in pore water and shifting metal distribution toward less mobile fractions. Zn, Pb, and Cd showed reduced presence in the exchangeable phase under compost treatment, indicating greater stabilization. The compost also promoted the binding of metals to reducible and oxidizable fractions, particularly for Pb and Cd. In contrast, dried algae led to higher EC and TOC due to the release of soluble organic compounds and salts, which could enhance the mobility of certain PTE, especially Cu and As.

Arsenic displayed increased mobility under both amendments, likely due to its anionic nature and competition with phosphate ions, abundant in the amendments. Sequential extraction revealed a concerning rise in As in the exchangeable and reducible fractions, mainly under compost treatment. Enzyme activity assays confirmed the positive impact of both amendments on microbial function, with algae promoting higher dehydrogenase activity.

In conclusion, composted C. prolifera shows promising potential to immobilize PTE in mining tailings while contributing to soil biological restoration. Although dried algae can enrich organic matter, its lack of stabilization may lead to unintended metal remobilization. The use of invasive algal biomass for environmental remediation offers a circular, sustainable strategy for managing both marine and terrestrial pollution.

KEYWORDS

Mar Menor, eutrophication, Caulerpa prolifera, trace element mobility, mining waste, organic amendments, sequential extraction, circular economy

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GT 11 - 693 - P

ASSESSMENT OF MICROPLASTIC CONTAMINATION IN COASTAL SANDY SOILS OF SOUTHERN ITALY USING MULTI-METHOD EXTRACTION AND SPECTROSCOPIC CHARACTERIZATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The extraction and characterization of microplastics (MPs) from terrestrial environments present significant methodological challenges due to the heterogeneous nature of soil matrices. This study assesses the presence and composition of MPs in sandy soils from a coastal pine forest in the Molise region of Southern Italy, an area periodically affected by wildfires. Multiple extraction protocols were employed to isolate MPs, including dry-sieving, density separation using sodium iodide (NaI) solution, and water extraction from undisturbed soil columns. These were followed by ATR-FTIR spectroscopy and SEM-EDS to identify and characterize the extracted MPs.

Dry-sieving enabled the classification of MPs into three size fractions and facilitated manual separation under a Nikon SMZ645 stereomicroscope. From 10 kg of soil, up to 100 MPs were isolated, consisting primarily of fibres and fragments. These were subjected to ATR-FTIR analysis using a Shimadzu IRSpirit spectrometer with a QATR-S single-reflection accessory. Spectra were recorded in the range of 4000–400 cm^{-1} and compared with standard polymer libraries to determine MP composition. Complementary SEM-EDS analysis was conducted on MPs isolated through NaI-based density separation and water-extraction from undisturbed soil columns. SEM imaging provided high-re solution morphological data, revealing varied degradation patterns among the MPs, while EDS analysis indicated the presence of inorganic additives and surface-associated elements, offering insights into environmental exposure and potential sources.

Results demonstrate that dry-sieving is effective for the recovery of larger MPs, while NaI density separation is more efficient for isolating smaller MPs (<0.8 mm), though it involves a more complex and time-consuming protocol. The water extraction method preserves soil structure and may be useful in studies requiring minimal disturbance. However, organic and mineral interferences can complicate spectral interpretation, especially in ATR-FTIR analysis of MPs from undisturbed columns.

This study highlights the importance of employing multiple complementary extraction and identification methods to overcome the limitations posed by complex matrices. It also underlines the need for standardized protocols to enhance reproducibility and comparability across studies. The combined use of ATR-FTIR and SEM-EDS provides a robust analytical framework for the detection and characterization of MPs in soil, contributing valuable data to the understanding of terrestrial microplastic pollution in wildfire-affected Mediterranean ecosystems.

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GT 11 - 694 - P

SUCROSE-BASED CARBON FOAMS TAILORED FOR PAH-CONTAMINATED SOILS: GREEN SOLUTIONS FOR SOIL POLLUTION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants with toxic, mutagenic, and bioaccumulative properties, representing serious environmental and health risks. Major anthropogenic sources include fossil fuel combustion and steel or petrochemical industries, which act as localized but high-impact emission sources due to the diffuse nature of their pollution. Numerous studies have reported elevated concentrations of these compounds not only in industrial areas [1], but also in agricultural soils across Europe. In this context, porous carbon materials have emerged as promising soil amendments for the immobilization of hydrophobic organic contaminants [2].

This study evaluates sucrose-derived carbon foams as sustainable amendments for PAH-contaminated soils. The foams were synthesized from this renewable precursor using simple and scalable procedures [3]. To tailor their porous structure and surface chemistry, various additives (citric acid, phytic acid, and iron nitrate) were incorporated during synthesis. The resulting materials were characterized by nitrogen adsorption isotherms, scanning electron microscopy (SEM), and elemental analysis to determine their textural and chemical properties. Batch experiments were carried out using a soil of industrial origin to assess the amendments’ effectiveness in reducing both total PAH concentrations and their bioavailability.

The results demonstrated that the application of sucrose-derived carbon foams led to significant reductions in total PAH content, with decreases of up to 75%. More notably, the bioavailable fraction of PAHs was reduced by over 90% in some treatments. The enhanced performance was closely associated with the presence of micro- and mesoporosity and increased aromaticity. This latter feature promoted stronger PAH adsorption through π–π interactions. In conclusion, sucrose-derived carbon foams represent efficient and sustainable tools for mitigating PAH contamination in soils, through their structural and chemical optimization.

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GT 11 - 700 - P

SEAWEED-BASED AMENDMENTS FOR REDUCING POTENTIAL TOXIC ELEMENTS MOBILITY IN CONTAMINATED MINING SOIL: A CIRCULAR APPROACH FROM THE MAR MENOR

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The Mar Menor coastal lagoon has experienced severe eutrophication in recent decades. One major consequence has been the proliferation and accumulation of opportunistic macroalgae, notably Caulerpa prolifera, which has displaced native algae and disrupted local ecosystems. This study assesses the valorisation of this algal biomass, otherwise considered a nuisance waste, as a soil amendment to remediate trace element-contaminated soil affected by arsenopyrite tailings from an old silver mine (Madrid, Spain).

A four-week incubation experiment was conducted using two types of organic amendments derived from the Mar Menor: dried algae and algae-based compost. Each was applied at 3% (w/w) to contaminated mining soils. The primary objective was to evaluate the effect of these amendments on the mobility and partitioning of potentially toxic elements (PTEs), particularly As, Cd, Cu, Pb, and Zn. Pore water was sampled weekly to assess changes in pH, electrical conductivity (EC), total organic carbon (TOC), and dissolved PTE concentrations. Following incubation, the BCR sequential extraction method was used to analyse PTE distribution across exchangeable, reducible, oxidizable, and residual fractions. Additionally, dehydrogenase and total hydrolase activities were performed to assess the recovery of soil microbial function.

The compost amendment showed a consistent ability to increase pH and TOC while significantly decreasing PTE mobility. This was evident both from the decline in PTE concentrations in pore water and from the redistribution of PTE from exchangeable to less bioavailable reducible and oxidizable fractions—particularly for Cd, Cu, Pb, and Zn. In contrast, the dried algae amendment led to initial TOC and EC surges, but showed limited immobilization capacity and, in some cases, increased PTE solubility due to organic compound release during decomposition. Arsenic showed a slight increase in exchangeable forms under compost treatment, potentially linked to complexation with humic substances.

Enzymatic activity results supported the role of compost in enhancing microbial function, with significant increases in dehydrogenase activity suggesting improved soil biological conditions. Total hydrolase activity showed a less consistent response, likely reflecting reduced microbial stress in amended soils.

These findings support the use of C. prolifera-based compost as an effective amendment for stabilizing trace elements in mining-impacted soils. This approach not only mitigates the ecological risk posed by PTEs but also aligns with circular economy principles by transforming an invasive algal waste into a valuable remediation resource.

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GT 11 - 781 - P

THE EFFECT OF PH AND SOIL AMENDMENTS ON THE SOLUBILITY OF COPPER IN SOILS AFFECTED BY COPPER SMELTERS WITH PHYTOSTABILISATION IMPLEMENTED.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Soil contamination with toxic elements occurs only locally in Poland, but there are places, such as areas surrounding copper smelters, with high or very high concentrations of trace elements in soils. The contamination was caused there by massive emissions of sulphur dioxide and heavy-metal-rich dust. The impacts of smelters onto the environment, extremely strong in the past, have been considerably reduced, but previous activities resulted in the accumulation of Cu and other toxic elements (for example, Pb, As) in soils. As a remediation strategy, phytostabilisation was applied in the 1980s and 1990s to reduce environmental risk. The remediation involved immobilisation of contaminants by neutralising the acidic pH of the soil (liming), improving its sorption capacity and planting trees. Soils surrounding the smelter Legnica are relatively homogeneous. They represent mainly Luvisols developed from loess of various thickness (from tens of centimetres to over 1 m) overlaying loams and fluvioglacial sands and gravels. Despite the use of phytostabilisation, a risk of remobilisation of contaminants still exists, which may be caused by soil acidification (natural in Polish climatic conditions) or the impacts of organic substances that can form soluble compounds with Cu. The research was conducted as a pot experiment in 1 kg mini-pots. The solubility of Cu in soils was examined depending on varying levels of soil contamination, pH, organic matter input, mineral fertilisation and the run of time. The soil material for the experiment was collected from the sites with three different levels of contamination, corresponding to Cu concentrations in the ranges: 300-400 mg Cu/kg (soil I); 800-1000 mg Cu/kg (soil II) and 7000-8000 mg Cu/kg (soil III). Soil pore water was collected using MicroRhizon samplers . The concentrations of Cu in pore water were measured after 7 and 21 days of incubation. The highest Cu concentrations were found after 7 days in soil pore water obtained from the most heavily contaminated soil III under strongly acidic conditions (pH = 3,98), with fertilisation applied, where they reached 8940 mg Cu/L. In the pore water of the same soil, after liming, Cu concentration after 7 days of incubation was as low as 1.17 mg Cu/L. After 21 days of incubation, the concentrations of Cu in acidified soils were lower than those after 7 days (with maximum 3300 mg/L), while in the limed soils they tended to increase slightly in comparison with those after 7 days, reaching 5.87 mg/L. The research has shown that the main factor influencing the release of Cu into soil pore water was the highly acidic pH of the soil (this was particularly noticeable at pH<4.5).



GT 11 - 786 - P

CLIMATE CHANGE IMPACT ON SOIL SUITABILITY FOR WHEAT AND SUGAR BEET IN THE TADLA IRRIGATED PLAIN - CENTRAL MOROCCO

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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We studied the climate change impact on the agricultural soil suitability for wheat and sugar beet, for the four main soil types of the Tadla irrigated plain in Central Morocco: Kastanozems, Vertisols, Chernozems, and Luvisols. The impact was assessed through the mapping of the actual suitability and the modeling of its future pattern. The soil suitability evolution was considered as a reflection of the impact of the projected changes in temperature and rainfall on the yields of wheat and sugar beet, between a reference period (1986-2005) and a future period (2041-2050). The actual soil suitability for the two crops was mapped using a dataset of the chemical, physical and hydrodynamic characteristics of the soil units of the perimeter. The soil potential was scored using the guidelines of the FAO GAEZ (Global AgroEcological Zoning) framework, using data of soil characteristics that are known to impact the soil behavior under irrigation in Central Morocco. The reference and future periods' daily precipitation and temperature dataset that was used for the crop model calibration and the future period yield simulations, was extracted from the daily bias-corrected dataset of the RICCAR program. The climate scenario considered was RCP 8.5. After the elaboration of the actual soil suitability maps for the two crops and the crop model calibration, wheat and sugar beet reference and future yield series were simulated and the suitability evolution for each soil type was determined accordingly. The results showed projected yield reductions for the two crops and the four soil types of the perimeter, with higher decrease rates for sugar beet. Overall, a soil suitability downgrade from high to medium was indicated for 68% of the perimeter's soils for the case of wheat and for 86% for the case of sugar beet. The Student t test showed that the yield reduction was significant for sugar beet on the four soil types, while the decrease was significant for wheat on Kastanozems. The study showcased the characteristic variability of the response to climate change that the main soil types in the irrigated areas of Central Morocco do express.

KEYWORDS

Soil suitability, climate change, Wheat, Sugar beet, Tadla, Morocco.

GT 11 - 794 - P

SOIL CONTAMINATION WITH ARSENIC IN POLAND – REVIEW OF CONTAMINATED SITES, ASSESSMENT OF RELATED ENVIRONMENTAL RISK AND THE EFFECTS OF PHYTOSTABILIZATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Arsenic is one of the most toxic elements, therefore the areas contaminated with it require special attention. Soils strongly polluted with arsenic occur typically in the sites of former arsenic ore mining and processing. There are several such sites in Poland, located mainly in the Sudetes, in particular in Złoty Stok (formerly the largest European producer of arsenic), Radzimowice and Czarnów. Arsenic concentrations in soils of those areas locally exceed 1%, being by several orders higher than the permissible concentrations set by Polish law, which are in the range of 10-100 mg/kg, depending on the type of land use and soil properties. Extremely high concentrations of As were found in various types of land, both on mine and processing heaps, as well as in grasslands and forests. Remediation of excessively contaminated soils should be performed to eliminate the risk posed by arsenic to human health, ecosystems and biota. As it would not be possible to remove arsenic from soils in such large areas, the remediation measures should be based on phytostabilization, i.e. arsenic immobilization in soils while ensuring the optimal growth of plants and possibly limited arsenic uptake. This is particularly important because various plants constitute food for both wild and farm animals. EU legal regulations allow the maximum concentration of arsenic in fodder at the level of 4 mg/kg.

This communication will present a review of literature and the results of our studies on the survey of As in soils in various areas in Poland, in particular in the Sudetes, as well as on its forms and mobility in soils. Particular emphasis will be put on the effects of pH, organic matter and redox conditions on arsenic solubility. The factors that determine arsenic uptake by plants growing on mine heaps and on grasslands in highly polluted areas will be discussed. Our research confirmed the literature knowledge that the uptake of arsenic by plants is generally low. Despite this, we reported several cases of relatively high As concentrations in the above-ground parts of plants that exceeded 4 mg/kg and sometimes were higher than 100 mg/kg. Particularly high As concentrations in plant shoots were found, among others, in horsetail Equisetum spp. and in the grasses Calamagrostis epigejos and Agrostis capillaris. These two grass species showed very high differences in As uptake which suggests that specific ecotypes with high tolerance may have developed in polluted areas. Preliminary results of studies on the characteristics of these tolerant grass ecotypes will be presented and possible mechanisms of their resistance to high As concentrations in soil, including the role of soil biota, will be discussed. Against this background, the environmental risk associated with the presence of As in soils, in different scenarios of their use and treatment, will be assessed.



GT 11 - 803 - P

PERFORMANCE OF ESA-CCI-SM SATELLITE PRODUCT FOR ESTIMATING SOIL WATER DEFICIT: A CASE STUDY IN NE PORTUGAL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The Mediterranean climate is characterised by hot and dry summers and water deficit in soils. Monitoring soil water deficit is of crucial importance in Mediterranean cropland, allowing a more cost-effective soil and water management. Satellite-borne data sources provide high temporal resolution information but usually lack the spatial resolution to adequately account for soil variability, namely on the physical-chemical properties that affect soil water storage capacity. As a case study located in Bragança, NE Portugal, the present work aimed at exploring the use of ESA-CCI-SM satellite product to estimate water deficit for a wide range of soil water storage capacities. A satellite-borne soil moisture data series (ESA-CCI-SM product) was clipped for Bragança area (25 x 25 km pixel). Temperature and precipitation (P) records of a weather station located in Bragança were used to compute monthly reference evapotranspiration (ET0, Thornthwaite) and the soil water balance (SWB, Thornthwaite-Mather) along the same period (2003-2016, 168 months). SWB were computed for soil water storages (Smax) representing the Smax range of regional soils (25, 50, 75, 100, 150 mm). Following earlier work by the authors, monthly soil water deficit series (SWD), obtained for the 5 Smax, were analysed and compared with the SM monthly averages series, using basic statistical methods. Average annual P and ET0 in the study period were 750 and 711 mm, respectively. In all years, SWD occurred from June to September, with peaks in July and August (ca. 110 mm each), but it was also recorded in February and in November (1 out of 14 years). Annual SWD decreased linearly with Smax increase (R^2=0.994), from 400 mm (Smax 25 mm) to 290 mm (Smax 150 mm). The number of SWD months also decreased in the same range of Smax, from 77 to 74 out of 168. Linear regression models relating SWD to SM monthly data for each Smax were derived and applied to estimate SWD in dry months. Model performance declined with Smax increase, from Smax 25 mm (R2=0.928) to Smax 150 mm (R2=0.873), while SEE remained similar along the Smax range (23 mm). Model parameters are well correlated (R2>0.95) with Smax, allowing the integration in a single model the two variables (SM and Smax). Dry months (SWD>0) were discriminated from non-dry (SWD=0) by SM, respectively lower or higher than 0.21 m3 m-3, with 91% (Smax 25 mm) to 94% (Smax 150 mm) matching frequency. Median SM in the whole Smax range was 0.14 and 0.25 m3 m-3, for dry and non-dry months, respectively. Performance reached encourages the application of the regression models derived for estimating SWD from SM, still with a considerable uncertainty due to the high SEE obtained. As the range of Smax tested was quite large, the regression models can be applied to deliver remote-based estimates of SWD accounting for the variability of soil water storage capacities found in NE Portugal.

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GT 11 - 827 - P

SEED PELLETING WITH NATIVE MICROORGANISMS AND ORGANIC AMENDMENTS FOR DRYLAND RESTORATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Arid soils are highly vulnerable to degradation, which reduces their capacity to support vegetation and accelerates ecological processes such as desertification and biodiversity loss. However, restoring these ecosystems through vegetation establishment is particularly challenging due to limiting factors such as nutrient scarcity, water deficiency, and severe erosion. These constraints often result in low germination rates and poor seedling survival.

In this study, we explored the use of pelleted seeds as a strategy to enhance seedling emergence and early growth under arid conditions. Pellets were formulated by combining a consortium of three bacterial strains and the cyanobacterium Nostoc commune. All microbial strains were isolated from native biological soil crusts and exhibited plant growth-promoting (PGP) properties. These were incorporated alongside organic amendments derived from locally available agricultural residues, with the aim of improving nutrient availability and promoting plant development. Stipa capensis, a native grass species typical of arid environments, was selected as the model organism. Seedling emergence was recorded, and growth parameters - including fresh biomass, shoot length, and root length - were measured ten days after germination. To further explore the impact of microbial inoculation, root and shoot tissues were analyzed using high-throughput sequencing to assess changes in the diversity and composition of endophytic bacterial and fungal communities.

Preliminary findings showed that neither microbial inoculants nor organic amendments alone led to a significant improvement in seedling emergence. However, the combination of both treatments resulted in a marked increase in root biomass. This trait is particularly important for plant survival in arid soils, as it enhances the ability to access water and nutrients. Additionally, microbial inoculation, particularly the combination of bacteria and cyanobacteria, altered the composition and structure of the plant's endophytic microbiome.

Overall, these results highlight the promise of seed pelleting technology that integrates beneficial microorganisms with organic amendments as a viable approach for ecological restoration in drylands. The observed enhancement of root development and shifts in microbiome composition may contribute to better seedling establishment under harsh environmental conditions. Nonetheless, further research is necessary to refine pellet composition, gain deeper insight into plant-microbe interactions, and evaluate long-term outcomes on plant performance and soil ecosystem resilience.

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GT 11 - 844 - P

COMPARISON OF A SLOW-RELEASE NANOMATERIAL-BASED FORMULATION OF THE HERBICIDE MESOTRIONE WITH THE COMMERCIAL PRODUCT: INFLUENCE OF SOIL PROPERTIES AND MICROBIAL IMPACT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The use of pesticides is essential to sustain agricultural productivity; however, only a small fraction reaches the intended biological target due to losses caused by transformation and transfer processes across the soil–water–air system. The development of slow-release formulations that provide the active compound at an effective dose to maintain bioactivity can reduce these losses and environmental impacts.

This study investigates the environmental behavior of the herbicide mesotrione in four soils with different physicochemical properties, highlighting the influence of pH, organic matter (OM) content, clay fraction, and the nature of the mineral matrix. In smectite-rich soils, the formation of organo-mineral complexes enhances the aromatic character of OM, increasing the affinity for mesotrione adsorption.

Dissipation assays comparing the commercial formulation (CF, Callisto®) with a previously developed slow-release formulation (SRF) based on nanomaterials (Galán-Jiménez et al., 2020) showed extended DT_{50} values in all tested soils (21–62% increase; Table 1), with minimal impact on soil microbial functionality. In contrast, the commercial formulation caused a pronounced reduction in microbial activity as determined by the dehydrogenase activity. Although the diversity index did not change, some modification of bacterial composition was observed.

These results are directly linked to the SRF formulation exhibiting approximately 50-fold lower toxicity compared to the commercial product, as measured by inhibition of Vibrio fisheri luminescence.

Formulation[1]	Soil[2]	k (day^{-1})	R^2	DT_{50} (d)	DT_{90} (d)
CF	AL	0.057±0.004	0.968	12.2	40.5
	CR	0.093±0.010	0.978	7.5	24.5
	LB	0.088±0.007	0.957	7.9	26.3
	LT	0.111±0.004	0.994	6.2	20.7
SRF	AL	0.047±0.002	0.976	14.7	49.0
	CR	0.068±0.007	0.908	10.3	34.1
	LB	0.064±0.003	0.990	10.8	36.0
	LT	0.069±0.005	0.967	10.1	33.4

1. CF: Commercial formulation; SRF: Slow-release formulation.
2. AL: silt loam soil; CR: sandy clay loam soil; LB: clay soil; LT: loam soil

Table 1. First-order dissipation parameters of Mesotrione as a function of the formulation and soil.

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GT 11 - 849 - P

IBUPROFEN-ENHANCED DISSIPATION IN AGRICULTURAL SOILS BY A DEGRADER MICROBIAL CONSORTIUM. EFFECT OF SOIL ADSORPTION.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Ibuprofen (IBP) is a widely used drug of environmental concern as emerging contaminant. The low elimination rates of IBP by wastewater treatment plants (WWTPs) and its accumulation in sewage sludge are the main sources for entering IBP into the environment: effluents are used for soil irrigation and sewage sludge as soil fertilizer. Once ibuprofen is present in soil as pollutant its remediation can be carried out by microbial degradation using bio-augmentation, using specific microbial species to facilitate IBP biodegradation.

This study describes the application of an IBP-degrading consortium to accelerate its dissipation in three soil with different physicochemical properties. Adsorption-desorption isotherms of IBP in these soils were carried out in order to observe the effect of their properties on the success of the biodegradation process. IBP adsorption was well described by linear equations, and sorption constants Kd were determined, and normalized to the organic carbon content of the soils to obtain log Koc values. IBP desorption from soils were about 35-40% for soil A and 50% for soil C, but only <7% for soil E, being considered a quasi-irreversible adsorption, which could influence on the availability of IBP towards the degrader microorganisms.

For IBP dissipation experiments the percentage of remaining drug was measured after different incubation times during 45 days. Various treatments were carried out: (i) abiotic control, with NaN3 added to avoid biological activity; (ii) biotic control, with degradation by endogenous soil microflora; (iii) biotic degradation by the IBP-degrading consortium. The kinetic model that better fit the degradation curves was the simple first-order model (SFO) and the corresponding kinetic parameters are shown in Table 1. In the abiotic control, 76% - 86% IBP remained in the soil mainly due physico-chemical sorption to soil surfaces. The calculated DT50 values (time to decline to half the initial IBP concentration) were similar for soils A and C (171 and 159 days, respectively), but much higher for soil E (342 days), related to the lower desorption capacity of IBP observed for this soil.

The extent of IBP dissipation by the endogenous soil microflora and by bio-augmentation with the IBP-degrading consortium reached 100%, but with a great difference in the value of the constant K (corresponding to the rate of IBP dissipation), which increased about 12-, 5.5- and 31-fold for soils A, C and E, respectively. DT50 values also decreased drastically, since for endogenous microflora were 3.3, 3.3 and 12.2 days for soils A, C and E, respectively, and were even lower, only 0.3, 0.6 and 0.4 days, when the degrading consortium was added. It is worth highlighting again the case of soil E, that presented a quasi-irreversible IBP adsorption, in which K increased about 31-fold and DT50 values decreased 30 times when the system was bio-augmented with the selected consortium.

Table 1. *Kinetic parameters calculated from ibuprofen dissipation curves in soils under different treatments.*

Soil	Treatment	K ($days^{-1}$)	DT_{50} * (days)	Extent of dissipation (%)	R^2
A	Abiotic control	0.004	171	23.5	0.9012
	Endogenous microbial flora	0.209	3.3	100	0.9842
	Consortium C7	2.495	0.3	100	0.9999
C	Abiotic control	0.004	159	18.0	0.9195
	Endogenous microbial flora	0.212	3.3	100	0.9983
	Consortium C7	1.176	0.6	100	0.9997
E	Abiotic control	0.002	342	14.0	0.9379
	Endogenous microbial flora	0.057	12.2	100	0.9832
	Consortium C7	1.751	0.4	100	0.9999



GT 11 - 858 - P

GEOCHEMICAL FRACTIONS OF PB AND NI IN APPLE ORCHARD SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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While inputs from natural sources constitute a significant burden of trace elements, for most elements the contribution from anthropogenic sources is much greater than from natural sources, raising environmental and health concerns [1]. Heavy metals from anthropogenic sources also tend to be more mobile and therefore more bioavailable compared to pedogenic or lithogenic sources [2]. The contribution of anthropogenic sources can be more reliably determined by the amount of heavy metals in the non-residual fraction rather than their total amount. In surface soils (0-10 cm), the contribution of anthropogenic sources to Cu, Zn, Pb and Ni in the non-residual fraction, i.e. the readily and potentially bioavailable and mobile fraction, was 51%, 70%, 24% and 49%, respectively [3].

Contamination of soils and arable land with trace elements such as Cu, Zn and Pb can occur due to the transfer of these elements into the fertilizer during the production of phosphorus fertilizers from phosphate rock [4; 5], the metal content in phosphate fertilizers may increase with the depletion of high quality phosphate rock in the world [6], and the potential of phosphorus fertilizer to increase the amount of heavy metals in soils is considered as an environmental concern [7]. When 1 ton of phosphorus fertilizers such as superphosphate and TSP are applied to the soil, Cu (20-138 g ha-1), Zn (55-235 g ha-1), Pb (3.13-17.4 g ha-1), Ni (19.2-44.2 g ha-1) are added to the soil [8]. Total Cu (0.2-1170 mg kg-1), Zn (15.81-1450 mg kg-1), Pb (3-225 mg kg-1) and Ni (0.5-151 mg kg-1) in phosphorus fertilizers; total Cu (3-93.5 mg kg-1), Zn (96.3-424 mg kg-1), Pb (3.3-240 mg kg-1) and Ni (<0.25-35 mg kg-1) in micronutrient fertilizer; total Cu (12-50 mg kg-1), Zn (1.3-25 mg kg-1), Pb (60 mg kg-1) in pesticides were determined [7; 8; 9; 10; 11; 12; 13; 14; 15].

It was concluded that the determination of high amounts of total Cu, Zn and Pb in agricultural soils compared to the reference soil was the result of long-term application of high amounts of fertilizers and pesticides-fungicides and that the phosphorus and potassium fertilizers applied were the main source of anthropogenic effect in the soil since Cu, Zn, Pb, P and K were in the same principal component and group according to principal component and cluster analysis [16].

In our study, soil samples were taken from depth of 0-20 cm of apple orchards. In order to evaluate the behavior, mobility, bioavailability and phytotoxicity of Pb and Ni elements in the soil, total and available Pb and Ni as well as seven different geochemical fractions of Pb and Ni (water soluble and exchangeable, bound to carbonates, bound to Mn oxides, bound to amorphous Fe/Al oxides), bound to crystalline Fe oxides, bound to organic and sulfides, residual fractions) were determined by sequential extraction and compared with control samples. Additionally, the relative distribution of Pb and Ni among fractions and their relationship with the available P, Cu and Zn in the soil were revealed.

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GT 11 - 868 - P

INFLUENCE OF COMPOSTED SLUDGE, BIOCHAR, AND RED MUD ON THE PHYTOAVAILABILITY AND ORAL BIOACCESSIBILITY OF AS, BA, SN, PB AND W IN CONTAMINATED AGRICULTURAL SOIL: IMPLICATIONS FOR HUMAN EXPOSURE AND ENVIRONMENTAL RISK ASSESSMENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Mining activities generate large amounts of metal(loid)-rich waste, which remains exposed to water and wind erosion. These fine, unconsolidated wastes, stored as heaps or tailings ponds, lack protective measures, leading to the dispersion of contaminated particles into surrounding soils. The transfer and toxicity risks of these inorganic contaminants in the food chain depend on their physical and chemical speciation rather than their total concentrations. Total content alone is insufficient to assess metal(loid) mobility or bioavailability to organisms and plants. As a component of the remediation and management of contaminated sites, whether industrial or mining, revegetating contaminated soils represents a methodical approach aimed at reducing the associated risks. This approach, known as phytostabilization, aims to limit the dispersion of contaminants in soils and, consequently, reduce human exposure. As part of the phytostabilization-assisted re-functionalization of soils, the use of organic soil improvers has been shown to improve the physicochemical properties of soils and limit the mobility and bioavailability of major metallic elements in contaminated soils, while at the same time increasing the recoverable biomass of cultivated plants.

The objective of this study is to assess the speciation, phytoavailability, and bioaccessibility of metal(loid)s (As, Ba, Cu, Sn, Sb, Pb, Zn and W) in contaminated agricultural soil before and after the cultivation of white lupin (Lupinus albus). Furthermore, the impact of three various amendments (composted sludge, biochar, and red mud) will also be investigated. Compartmentation of metal(loid)s has been determined by BCR sequential extraction. In vitro methods (UBM and SBET) have been used to simulate the physiological mechanisms of digestion and to estimate the actual quantity potentially absorbable of metals by the human body.

The results highlight that the phytoavailability and bioaccessibility of each metal(loid) are quite different and also amendment dependent. The effects of amendments on As, Ba, Cu, Sn, Sb, Pb, Zn and W-oral bioaccessibility and phytodisponibility are contradictory and do not show any trend. Finally, these differences may be related to the mineralogical cortege of contaminated agricultural soil i.e., the nature and stability of the metal(loid)s bearing phases and amendment type.

GT 11 - 872 - P

MAPPING PESTICIDE RESIDUES IN EUROPEAN AGRICULTURAL SOILS: THE CRUCIAL IMPACT OF LONG-TERM AGRICULTURAL PRACTICES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Pesticide contamination of soil poses substantial risks to both the environment and human health. The impact of long-term agricultural practices on pesticide residues in European soils was investigated in this study. Soil samples were collected from 92 locations across eight European countries, representing a range of fertilization and tillage practices over a minimum of 10 years. The soils were categorized into four usage intensity levels based on the degree of tillage and type of fertilization. A total of 60 pesticide residues, including insecticides, fungicides, herbicides, and metabolites, were analyzed using HPLC/MS/MS and GC/MS multiresidue methods. Physicochemical and microbial soil properties were also assessed to evaluate the soil health indicators. The preliminary results showed that soils subjected to middle-intensive management practices, such as reduced tillage and mineral fertilization, had higher pesticide residues than those managed more sustainably with organic fertilization and reduced or no-tillage (Figure 1). Soil under less intensive management accumulated more organic matter, leading to increased microbial biomass and activity, which enhanced pesticide biodegradation. Random Forest analysis and Structural Equation Modelling (SEM) were used to model the abiotic and biotic factors influencing soil pesticide residues. These findings highlight the crucial role of long-term agricultural practices in determining the presence and concentration of pesticide residues in European soils, with implications for soil health and environmental sustainability.

ACKNOWLEDGEMENTS

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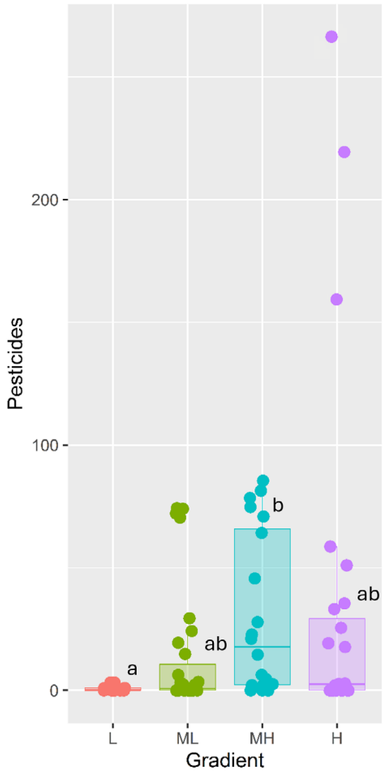


Figure 1: Box plot illustrating pesticide residue concentrations (ppb) detected in 92 soil samples, comparing management intensities: low (L), middle-low (ML), middle-high (MH), and high (H). Different letters above each bar denote significant differences at $p < 0.05$. [These classifications were determined by fertilization type (MN: mineral; OG: organic) and tillage intensity (RT: reduced tillage; ST: standard tillage; NT: no-tillage). i) L includes OG fertilization with RT or NT; ii) ML includes OG fertilization with ST and MN fertilization with NT; iii) MH includes MN fertilization with RT; iv) and H includes MN with ST].



GT 11 - 875 - P

REMEDIATION OF BOSCALID-POLLUTED SOIL BY PHOTOCATALYTIC TREATMENT USING TIO2 UNDER SOLAR IRRADIATION

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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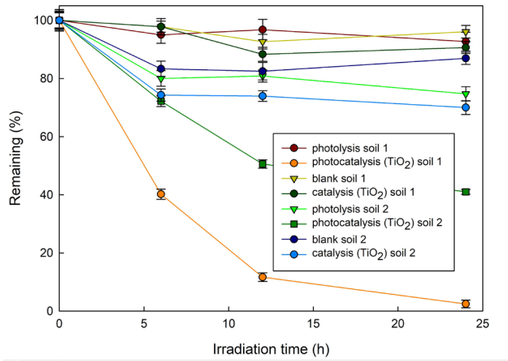
Pesticide contamination of soil poses significant risks to the environment and human health. Therefore, the application of cheap and effective remediation technologies that can remove these substances from the soil is extremely urgent. Advanced oxidation processes (AOPs) have received increasing attention because of their distinctive advantages such as low energy consumption, high efficiency, rapid start-up, and environmental friendliness. Among them, heterogeneous solar photocatalysis using the most popular photocatalyst (TiO2) has rarely been applied to remove pesticides from agricultural soil. This is based on the light irradiation of TiO2 particles, which leads to the generation of reactive oxygen species with strong oxidation potentials, mainly •OH (E0 = 2.8 V). These radicals attack a wide range of pesticides. Consequently, these organic pollutants can be converted into simpler organic molecules that are eventually mineralized to CO2, H2O, and inorganic salts.

Boscalid is a succinate dehydrogenase fungicide that inhibits fungal respiration by blocking specific binding sites involved in the Krebs cycle. It is widely used to control various fungal diseases in crops and can be detected in high concentrations in various environments. This study discusses in detail the efficacy of the commercial photocatalyst titanium dioxide Degussa P25 for the elimination of boscalid fungicide from two soils at the laboratory scale under natural sunlight.

Photocatalytic experiments were carried out in spiked soils (1 mg kg−1) in August 2024. Four treatments were assayed: (i) addition of TiO2 to soils and sunlight exposure (photocatalytic treatment), (ii) addition of TiO2 to soils and dark exposure (catalytic treatment), (iii) catalyst-free soils with sunlight exposure (photolysis treatment), and (iv)catalyst-free soils but with dark exposure (blank treatment). Soil samples were exposed to sunlight on sequential days. Once optimized (concentration of TiO2, type of soil, and aged spiked soil), the photocatalytic process using sunlight was applied to reduce the residual levels of boscalid in the two soils. The results showed that photocatalysis using TiO2 enhanced boscalid degradation rates in comparison with the catalytic, photolytic, and blank treatments (Fig. 1). Therefore, our results suggest that photocatalytic treatment using TiO2 could be considered a promising technology to degrade pesticides in soil, and could also be applied on a larger scale.

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Evolution of boscalid residues during the treatments assayed in both soils

GT 11 - 894 - P

STUDY AND VERIFICATION OF AN INNOVATIVE SURFACTANT FOR THE REHABILITATION OF SOILS CONTAMINATED WITH PERSISTENT HYDROCARBONS.

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Soils contaminated with hydrocarbons pose a serious threat to the health of ecosystems, particularly when the contaminants persist for extended periods of time and become recalcitrant, rendering them difficult to remove. In this context, we are evaluating the effectiveness of a chemical surfactant that is not commercially available for this purpose, to mobilise and solubilise residual hydrocarbons in soils that have been historically contaminated and are being decontaminated in a biopile.

Preliminary data suggest that the native soil microbiota can tolerate the surfactant at various concentrations, indicating its potential compatibility with bioremediation strategies. This tolerance has been quantified using basal and substrate-induced respiration tests, which reflect the bacteria’s ability to maintain metabolic activity in the presence of the surfactant. These results demonstrate the adaptability of the indigenous microbial community to different surfactant concentrations in mobilised hydrocarbon degradation. Similarly, oxidisable carbon increases in samples containing the surfactant, indicating the mobilisation of these recalcitrant hydrocarbons into more readily available fractions.

The objective of this study is to optimise the application of the surfactant to maximise solubilisation of the contaminant while avoiding inhibition of the degrading microbiota. Future studies will incorporate other bioremediation techniques, alongside the characterisation of bacterial communities (e.g. via 16S ribosomal RNA sequencing) and the measurement of actual hydrocarbon degradation (TPH). This will enable a more comprehensive understanding of the rehabilitation of these contaminated environments. This combined approach (surfactant and bioremediation) could provide a sustainable solution for soils with persistent residual contamination where conventional technologies are ineffective.



GT 11 - 902 - P

EXPLORING THE RHIZOSPHERE OF A NATIVE PLANT FOR MINE SOIL PHYTOREMEDIATION: ISOLATION AND EVALUATION OF PLANT GROWTH-PROMOTING BACTERIA

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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Abandoned mining waste dumps pose a significant risk of contamination to surrounding areas due to water and wind erosion. With the aim of phytoremediating the bare mine tailings of a mine in the Sierra de Madrid, a native plant, Digitalis thapsi L., was selected. This plant grew in older tailings that had been naturally revegetated and was capable of accumulating large amounts of copper and arsenic, mainly in its roots. The rhizosphere soil adhering to the roots was collected and bacteria were isolated in copper and arsenic containing media, for use in the phytoremediation project. Four strains, identified as Bacillus proteolyticus, Bacillus cereus, Pseudomonas fluorescens, and Pseudomonas graminis, were selected to study their PGPB properties.

The following tests were carried out: a) qualitative evaluation of phosphate solubilisation capacity using the Pikovskaya medium; b) Quantification of indole acetic acid (IAA) production using the spectrophotometric technique described by Glickmann and Dessaux, 1995; c) Qualitative determination of siderophore production using the CAS method of Schwyn & Neilands (1987) modified (O-CAS) by Pérez-Miranda et al. (2007); d) determination of the NifH gene, associated with the ability to carry out biological nitrogen fixation.

With regard to the ability to solubilize phosphate, it was observed that three of the strains did solubilize phosphorus, but B. proteolyticus did not. As for indole acetic acid production, only the P. fluorescens strain was capable of producing indole acetic acid. Of the four bacteria studied, only both Bacilli had the NifH gene in its sequence, which is generally associated with biological nitrogen fixation. The O-CAS method for determining the ability to synthesize siderophores was not entirely conclusive, although initially all bacteria appeared to test positive.

Given that bacteria under study have different plant growth promotion capacities, a consortium of all of them is recommended for future studies on mine spoils remediation.

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GT 11 - 906 - P

POTENTIAL OF MICROORGANISMS IN THE REHABILITATION OF MINING-CONTAMINATED SOILS THROUGH GREEN REMEDIATION STRATEGIES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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Green remediation of soils contaminated by mining activities is proposed as a sustainable strategy based on the combined use of organic and inorganic amendments, vegetation, and beneficial microorganisms, with the aim of restoring soil functionality. In this study, we assessed the effect of the combined application of amendments (biochar and calcium carbonate) and plant growth-promoting rhizobacteria (PGPR) on the microbial functionality of contaminated soils from the Bustarviejo mine (Madrid), as well as their influence on the establishment and development of Digitalis thapsi, a species with phytoremediation potential.

The experiment was conducted under controlled conditions using 48 experimental units and considered two main factors: amendments (biochar, calcium carbonate, their combination, and a non-amended control) and bacterial inoculum. Three PGPR treatments were applied: I35 (Pseudomonas graminis strain), IC (a consortium composed of Bacillus proteolyticus, Bacillus cereus, Pseudomonas fluorescens, and the I35 strain), and a non-inoculated control (I0), with four replicates per treatment combination.

Microbial abundance was assessed via qPCR quantification of functional genes: amoA (nitrification in bacteria and archaea), BGH3 and FGH3 (cellulose degradation by bacteria and fungi, respectively), phoD (phosphorus cycle), and ureC (nitrogen cycle via urease). In parallel, the catalytic activity of the enzymes urease, β-glucosidase, and acid and neutral phosphatases was measured as indicators of soil metabolic activity. Additionally, shoot and root biomass of D. thapsi were measured to evaluate treatment effects on plant growth.

Results indicated that the combination of amendments, particularly calcium carbonate, together with the bacterial consortium IC, promoted the proliferation of microorganisms harboring key functional genes such as amoA and phoD. Similarly, in non-amended soils inoculated with either I35 or IC, an increase was observed in the abundance of genes such as ureC and those related to β-glucosidase activity. However, although amendment application enhanced the abundance of several genes associated with biogeochemical processes, this increase did not always translate into higher enzymatic activity. A significant correlation was only found between phoD gene abundance and phosphatase activity, while other associations were positive but not statistically significant.

These findings highlight the critical role of the interaction between soil, amendments, and microorganisms in the functional recovery of degraded soils. The sustained increase in key microbial groups, along with enhanced potential enzymatic activity, suggests a reactivation of essential processes for soil health, reinforcing the value of this strategy for the ecological restoration of contaminated mining sites.

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GT 11 - 916 - P

SOIL CONTAMINATION MONITORING: SPANISH PHOSPHATE WASTE CHARACTERIZATION USING SEM/EDS AND Γ-SPECTROMETRY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Fertilizer industries generate phosphate residues during their production process that concentrate the quantity of radionuclides initially present in the raw materials. Throughout years of production, an alternative storage for these residues has been their deposit in open-air ponds and stockpiles. Two Spanish areas are contaminated with phosphate wastes containing radionuclides and heavy metals: ponds near the Tinto River estuary (Huelva), and the ponds and stockpiles of El Hondón (Cartagena). The Huelva residues are phosphogypsum from phosphoric acid production, meanwhile, the Cartagena wastes come from phosphate processing, containing acid compounds with higher chemical reactivity. The aim of this work is to study, chemical and radioactively, samples from both areas and compare them. To this end, two techniques were used: Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM/EDS) and high-resolution γ-spectrometry (GS).

SEM/EDS is widely used in environmental studies to determine soil composition and assess contamination by trace heavy metals. In this work, the SEM/EDS technique was used to analyse the samples' composition by detailed elemental mapping. On the other hand, GS technique was used to determine the radioactive content of the phosphate wastes from both locations by identifying and quantifying γ-ray emitting radionuclides.

The SEM/EDS analysis of all the samples revealed common elements such as O, Ca and S, consistent when measuring phosphate wastes as they are typical phosphate mineral components. Both Huelva and Cartagena samples present the same elements except Cl, only detected in Cartagena likely due to acid-based phosphate processing. No radioactivity-related elements are included among the list of elements identified by SEM/EDS analysis.

Regarding the radioactive content, the γ-spectrum of the samples evidenced the presence of radionuclides exceeding the typical level found in non-contaminated soils of the areas. Specifically, Ra and U have been identified during the analysis of the spectrum of Cartagena's samples, while in the case of Huelva only Ra has been detected. This difference aligns with the expected waste composition of each industrial process: Ra partitions mostly into phosphogypsum, while U remains in solution during phosphate processing [1].

The radionuclides might not be detected by SEM/EDS due to concentrations potentially under the detection limit of the technique. Although radionuclides in the phosphate waste may be present only in trace amounts, they might still pose an environmental risk in terms of radiological protection and heavy metal contamination. Therefore, a combination of both techniques, GS and SEM/EDS, should be considered when addressing the composition of areas potentially affected by radioactive and chemical contamination for further mitigation and remediation.

ACKNOWLEDGEMENTS

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GT 11 - 941 - P

EFFECTS OF CONVENTIONAL AND BIODEGRADABLE MULCHES ON SOIL CHEMICAL PROPERTIES AND PLASTIC ADDITIVE RELEASE IN A SHORT-TERM BLUEBERRY PLANTATION IN SOUTHERN PORTUGAL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Among the potential sources of contamination in agricultural soils, the use of plastic mulch materials stands out. Mulching the soil surface along planting or seeding rows plays a fundamental role in reducing weed competition, improving water and nutrient use efficiency by crops, regulating soil temperature, protecting crops against diseases and pests, and ultimately increasing agricultural productivity [1], [2]. However, these plastic mulches contain a variety of additives, including stabilizers, plasticizers, UV inhibitors, and flame retardants, which can leach into the soil over time [3]. The accumulation of these emerging contaminants in the environment has raised growing concerns, particularly with regard to terrestrial ecosystems, as the soil can retain many of these substances, potentially leading to chemical contamination that may interfere with microbial activity and negatively affect soil fertility and overall ecosystem functioning [4]. Although European legislation does not yet specifically regulate the application of plastic mulch materials to soil, the FAO [5] recommends replacing conventional, fossil-based, non-biodegradable plastic mulch materials with biodegradable, bio-based alternatives to mitigate their negative environmental impacts.

In this context, and within the scope of the Portuguese Recovery and Resilience Plan, the Agri-Plast Project "Organization and Innovation for Reducing Agricultural Plastics", evaluated the chemical effects of different types of soil covers in a 2-year blueberry plantation. These included three biofilms (pine bark, Kraft® paper, and Kritifil®) and two conventional plastics (polypropylene and polyethylene). The hypothesis is that conventional plastic mulches have a more negative impact on soil quality than biofilms, due to both changes in soil chemical properties and the potential release of chemical additives.

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GT 11 - 945 - P

MICROPLASTICS POLLUTION IN SOIL ENVIRONMENT: CONTRIBUTION OF AGRICULTURE AND ASSOCIATED RISKS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Plastic pollution in soil is an increasing concern due to widespread plastic use and improper disposal. Microplastics (MPs) are well-studied in aquatic environments, where research on soil MPs remains limited. Plastic pollution in soil is closely related to surrounding industrial and human activities. These plastic particles persist in soil, affect soil health, and can potentially enter the human body through ingestion. This study examines the distribution of MPs(<0.1mm) in urban and peri-urban soils assess potential human exposure risks by investigating the MPs in different land use types in major cities of Pakistan. MPs concentration ranged from 120 to 4500 MPs/kg, with an average of 1156± 142 item/kg in different land use types. The highest MPs concentration was found in greenhouse soil (3350 ± 437 MPs/kg), followed by residential area soil (2341 ± 522 MPs/kg) and lowest in fish farm soil (128 ± 13 MPs/kg). HDPE dominated roadside (29.8%) and greenhouse soil (26.3%), while nylon was highest in industrial (27.7%) and greenhouse areas (20.2%). PE and PS exceeded 30% in sewage-irrigated and compost soils, PVC peaked in landfill (26.3%) and residential sites (17.1%), PP was high in crops (26.4%), and ABS was elevated in mulching and composted soils (~15%). White colored and fiber shaped MPs with 1-5mm sizes were most dominant. Soils were categorized as uncontaminated to moderately contaminated, assessed by the geo-accumulation index (Igeo). Residential and greenhouse were found to be extremely contaminated, with Igeo values ranging from 4.4 to 4.7 comparatively. EDI value of highly contaminated sites are about 20 times more for infant as compared to adults due to hand-to-mouth behaviour and low body weight. This study highlights the prevalence and potential hazards of microplastics (MPs) in both residential and agricultural soils, emphasizing the need for thorough health risk assessments of MPs in urban environments

KEYWORDS

Microplastics, Human Exposure Risk, Land Use Types, Geo-accumulation Index. Soil Pollution

ACKNOWLEDGEMENTS

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GT 11 - 951 - P

CONSERVATION TILLAGE, PHYSICAL PROPERTIES OF WARM-CLIMATE COLOMBIAN ANDISOLS, AND YIELD CORN (ZEA MAYS L.)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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In Colombia, mechanized soil-preparation practices are often carried out without consideration of soil type or physical condition, leading to excessive or unnecessary operations that accelerate physical degradation and reduce productivity. This study assessed the impact of three conservation-tillage schemes—No-Tillage (NT), Minimum Tillage (MT) and Reduced Tillage (RT)—on texture, bulk density (d.a.), total porosity, Infiltration Rate (IR), hydraulic conductivity (K_s) and Penetration Resistance (PR) in a Colombian Andisol, as well as on physiological variables of corn (Zea mays L.) including leaf number, stem diameter, root length and grain yield. A completely randomized block design (α = 0.05) was implemented at Montelindo Farm (Palestina, Caldas, Colombia).

Soil texture in all treatments was classified as sandy loam, sand content >60 %. Significant differences were found in d.a. and total porosity: RT showed the lowest d.a. (1.01 g*cm^{-3}), highest porosity (57.7 %) and greatest IR (78.94 cm*h^{-1}), whereas NT recorded the highest d.a. (1.18 g*cm^{-3}), lowest porosity (50.52 %) and lowest IR (50.89 cm*h^{-1}). K_s did not differ significantly among treatments but remained high (> 25 cm*h^{-1}). PR exceeded the critical value 1 MPa threshold in all systems (2.0–2.6 MPa) below 10 cm depth, limiting root development in Andisols. Surface compaction was greatest under NT—likely due to machinery traffic without soil disturbance—while MT and RT exhibited lower PR in the upper 30 cm. Leaf number and stem diameter differed among treatments: MT achieved the highest means (10.28 leaves; 21.33 mm stem diameter), and NT the lowest (9.26 leaves; 20.33 mm). Root length showed no statistical differences, although RT showed the highest mean value (21.7 cm). Grain yield was highest under RT, followed by MT and NT, with 3500, 2429 and 1167 kg*ha^{-1}, respectively. The tillage schemes evaluated influenced soil physical properties, crop physiological performance and final yield. MT enhanced vegetative growth, whereas RT was most efficient for grain production, indicating that appropriate soil preparation can optimize corn yield in warm-climate Colombian Andisols.

KEYWORDS

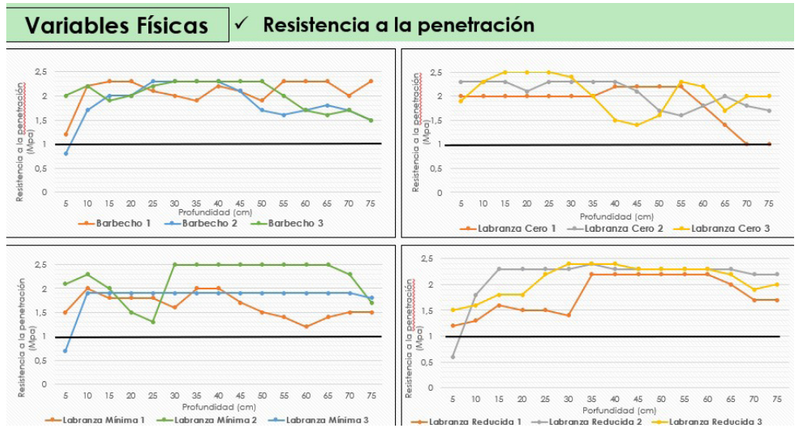
Andisols; conservation tillage; yield; bulk density; porosity; infiltration rate.

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GT 11 - 953 - P

PHYTOTOXICITY OF SOIL PORE WATER IN SOILS CONTAMINATED BY COPPER INDUSTRY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Heavy metals released into the environment by industry, particularly by smelting plants, pose a serious threat to ecosystems, especially soils, where they can persist for decades. Their ecotoxicity in soil depends not only on total concentrations but also on the chemical forms in which they occur and their mobility that is crucial in terms of their potential leaching into groundwater, entering trophic chains, and govering ecotoxicity. The basic remediation methods used for large areas surrounding industrial facilities, including smelters, is phytostabilization, the effectiveness of which can be enhanced by the appropriate application of soil amendments. This study assessed the phytotoxicity of soil water extracted from soils in the vicinity of the Legnica Copper Smelter that were limed over twenty years ago to immobilize toxic elements. Currently they are susceptible to secondary acidification. Soil samples were collected from three locations at varying distances (I, II, III) from the smelter. The soils had the texture of silt loam and slightly acidic pH and differed in the degree of contamination with copper (Cu: I – 369, II – 1227, III – 8250 mg/kg) and lead (Pb: I – 154, II – 480, III – 1637 mg/kg). The soils were adjusted to two pH ranges (4.0–4.5 and 6.8–7.0), amended with two types of additives: beech litter and mineral nitrogen fertilizer, and incubated at constant moisture (80% of field water capacity) for 7, 21, and 90 days. Subsequently, Cu and Pb concentrations were measured in soil pore water or extracts collected using both the MacroRhizon samplers and water extraction. The ecotoxicity of soil pore water or extracts was evaluated using the Phytotox test, based on seed germination and inhibition of roots and shoots elongation in seedlings of white mustard (Sinapis alba L.). The test results showed a strong correlation with Cu and Pb concentrations in soil pore water. The findings confirmed that under alkaline pH conditions, both metals considered were effectively immobilized, regardless of the amendment used. Cu concentrations in the solutions were significantly higher than those of Pb. The highest concentration of metals in pore water was found in the most heavily contaminated soil that was acidified and amended with nitrogen fertilizer. The results provide a valuable reference for predicting soil phytotoxicity under different future soil management scenarios

GT 11 - 954 - P

CONTROL OF FUNGICIDE LEACHING IN A VINEYARD SOIL WITH ORGANIC RESIDUE BARRIERS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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The application of fungicides is a widespread agricultural practice in vine cultivation to combat all types of fungal diseases that threaten the productivity of the wine sector. Inadequate practices when handling and washing agricultural machinery used in these phytosanitary treatments make vineyard areas susceptible to experience punctual contamination of groundwater by fungicides and demand the implementation of sustainable strategies to prevent or minimise this environmental impact. The aim of this work was to evaluate and compare the individual capacity of three organic wastes from different origin (spent mushroom substrate (SMS), green compost (GC) and vine pruning sawdust (VPS)) to control the leaching of the fungicides azoxystrobin, fluopyram and tetraconazole in undisturbed vineyard soil cores (40 cm x 9 cm i.d.) from La Rioja by arranging them as an adsorbent barrier (4.5g ~ 0.5 cm high) on the soil surface. Sandy loam soil cores were saturated with water, contaminated with the three fungicides (8 mg) and KCl (250 mg, tracer ion) from the top and washed with deionised water (60 mL) for 77 days under unsaturated flow conditions. The leaching curves of the three fungicides were delayed with respect to those of the tracer ion, and showed incomplete leaching in all treatments after washing with 8.2-11.0 pore volumes. The accumulated leaching curves in the soil without organic residues (control) and with the different organic residues as adsorbent barriers showed that fungicide leaching followed the order tetraconazole < azoxystrobin < fluopyram. The use of the three organic barriers decreased the leaching of fluopyram (1.4-1.5 times), azoxystrobin (2.7-3.7 times) and tetraconazole (3.9-8.2 times) compared to the control soil, with the VPS barrier generally showing a slight higher efficiency in reducing the leaching of the three fungicides. The distribution of the most hydrophobic fungicides, azoxystrobin and tetraconazole, in the soil profile after the end of the washing period showed a higher retention of both compounds in the surface section (0-8 cm) of the barrier soil, while in the control soil it was observed in the lowest section (32-40 cm). The distribution of fluopyram in the control and with barrier soil profiles was very similar, with the highest retained concentration observed in the lowest section of the soil cores (32-40 cm). The results show how the spreading of a thin layer of the tested organic residues contributes to significantly reduce the leaching of the studied fungicides in vineyard soils and could therefore be used as a strategy to control groundwater contamination depending mainly on the characteristics of the fungicide.

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GT 11 - 956 - P

DISSIPATION OF FUNGICIDES IN VINEYARD SOILS AMENDED WITH ORGANIC RESIDUES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Soil and water contamination by fungicides is a growing concern, as these compounds could be toxic and cause health and environmental problems. The use of different organic residues as soil amendments could limit the transport of fungicides from soil to groundwater and/or facilitate their dissipation, avoiding the diffuse or point pollution of waters due to the intensive use of these compounds in viticulture. This work was aimed to study the impact that spent mushroom substrate (SMS), green compost (GC) and vine pruning sawdust (PV), applied at a rate of 1.5% (on a dry weight basis) as amendments to a sandy loam soil from La Rioja and a loam soil from Galicia, had on the dissipation kinetics of the fungicides azoxystrobin, fluopyram and tetraconazole over time (i) and mass balance of 14C-azoxystrobin (ii) under laboratory conditions. The dissipation half-life (DT50) values followed the order fluopyram > tetraconazole > azoxystrobin in the different soils studied. The application of SMS and GC amendments slowed down the rate of fungicide dissipation and increased their persistence in both vineyard soils due to greater adsorption and lower bioavailability of the fungicides in solution to be degraded. The effect of the organic amendment differed depending on the fungicide, being greater for the dissipation of fluopyram, which had higher DT50 values in the amended soils compared to the control soils. The difference in degradation kinetics and variability in response to amendments indicate that the physicochemical properties of each fungicide are crucial in determining its fate in the soil and its interaction with amendments. The use of SMS and GC increased the persistence of the three fungicides in both La Rioja and Galicia soils (up to 1.3 times for azoxystrobin, 419 times for fluopyram and 1.4 times for tetraconazole), while PV decreased it in both soils (up to 1.4 times for azoxystrobin and tetraconazole, and 2.6 times for fluopyram). For azoxystrobin, a major proportion of fungicide was tightly bound to the amended soils from the start, and an apparent dissipation occurred in the PV-amended soils due to a higher formation of non-extractable 14C residues compared with the other amended soils. The bioavailable fraction of azoxystrobin extracted with water was lower in the amended soils compared with the unamended soils. These results highlight the need to select the optimum organic waste as an organic amendment in vineyards in order to use it as a strategy to retain fungicides and mitigate their potential to contaminate groundwater. However, it should be borne in mind that excessive retention can make fungicides unavailable for biodegradation, posing a threat to surface water quality through soil erosion given their high persistence and accumulation in amended soils.

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GT 11 - 957 - P

EFFECT OF GREEN COMPOST APPLICATION ON THE DISSIPATION OF IODOSULFURON-METHYL-SODIUM IN AN AGRICULTURAL SOIL UNDER WHEAT FIELD CULTIVATION AND ON SOIL CHARACTERISTICS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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The application of organic residues in agriculture contributes to replenish soil organic carbon (OC), improve soil fertility and biodiversity, reinforce aggregate stability and favour water infiltration. Moreover, the application of organic residues as a soil amendment can modify the behaviour of pesticides that are simultaneously applied to the soil. The objective of this work was to study the dissipation and persistence of iodosulfuron-methyl sodium on a sandy loam soil and this one amended with green compost (S+GC) grown with winter wheat under real field conditions. A field trial was carried out at the Muñovela farm (IRNASA-CSIC), whose experimental design consisted of 24 plots of 10 m2, including 12 control soil plots and 12 S+GC plots (~11 tC/ha). The plots were sown with soft winter wheat (200 kg/ha) on October 2024. Iodosulfuron-methyl-sodium (Hussar® Plus) was applied at the agronomic dose (D1) and double the agronomic dose (D2) on February 2024. Topsoil samples were taken from the plots to determine residual herbicide and metabolites concentrations at different times (0-126 days after herbicide application) and to study the evolution of their physicochemical and biological parameters. Dissipation half-life (DT50) values were up to 5 times lower for the herbicide compared with those of its metabolite metsulfuron-methyl. The residual amounts of herbicide and metabolites detected in the S+GC plots were higher, indicating a higher persistence over time in the GC-amended soil. The amounts of the metabolite formed were much higher than the amounts of iodosulfuron-methyl in all treatments. This is possibly explained by the interception of the herbicide by the plant at the time of application, the rapid dissipation of the herbicide (DT50=5-9 days) reaching the soil and/or the higher persistence of the metabolite (DT50=25-30 days) compared to that of the herbicide. The application of GC to the soil resulted in a significant increase in pH and electrical conductivity of the soil compared to the control, which was maintained throughout the experimental period. The increase in OC in the S+GC was 40% compared to the control at wheat harvest. Total nitrogen content increased up to 1.3 times during the wheat growing season in the S+GC compared to the control. Dehydrogenase activity, respiration and soil microbial biomass increased in the S+GC compared to the control during the growing season. Soil microbial structure, as determined by PLFAs analysis, showed no significant differences between the microbial groups in the soils without and with GC. An increase in wheat yield was observed in the S+GC compared to the control, although the differences were not significant.

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GT 11 - 981 - P

CLIMATE CHANGE VS. RAIN EROSIVITY (FUERTEVENTURA, CANARY ISLANDS, SPAIN)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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Climate change has led to global warming as a result of the human-related rise in greenhouse gas emissions. Projections by the IPCC based on different emission scenarios foresee, for example, a temperature increas of 4.4 oC by 2100 in the worst-case scenario. Likewise, these projections predict an increase in the intensity and concentration of the precipitation that could lead to a rise in the erosive potential of rain events, mainly in arid and semiarid regions. Fuerteventura (Canary Islands, Spain) is the most arid territory in the Canarian archipelago, with high risk of desertification in all its extent. In order to evaluate the impact of climate change in the erosion potential of the rain in this island, we have calculated different indexes to characterize precipitation concentration and erosive potential including the Precipitation Concentration Index (PCI), the Seasonal Index (SI) and the Modified Fournier Index (MFI) from monthly and annual precipitation values obtained from regional climate simulations. These simulations were driven by three CMIP5 models (GFDL–ESM2M, IPSL–CM5A–MR, and MIROC–ESM) over three periods (1980–2009, 2030–2059, 2070–2099) and two emission scenarios representative concentration pathway RCP 4.5 and RCP 8.5. Results highlight the difference between the models and scenarios. The MFI shows low values of rainfall erosivity for the island in the present scenario (1989-2009) and for all models, whereas the MIROC-ESM model shows the highest values of MFI, mainly located on the west coast of the island, for future scenarios of the RCP 8.5. PCI shows low seasonality for all scenarios and models except for the IPSL-CM5A model in the 2030-2059 RCP 4.5 and 8.5 scenarios. The model GFDL-ESM2M, however, shows a general decrease in the concentration of the precipitation (PCI) for future scenarios. The IPSL-CM5A model also shows the highest values of rainfall seasonality (SI) for all scenarios except for the 2070-2099 RCP 4.5, with increasing values of this index observed also for the 2070-2099 del RCP 8.5 MIROC-ESM model scenario. These results highlight that climate change effects on precipitation patterns and erosion potential in arid regions are expected and, therefore, need to be further evaluated in order to design effective mitigation plans that include a decrease in greenhouse gas emissions to reduce erosion risks in these regions.

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GT 11 - 992 - P

APPLICATION OF BIOMASS ASH AND FISH WASTE AS EFFECTIVE AMENDMENTS IN MINING SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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This study evaluates the effectiveness of local industrial wastes (biomass ash and fish waste) as amendments for contaminated soils from the Tharsis mining district in the Iberian Pyrite Belt (SW Iberian Peninsula). These soils, affected by mining activity, constitute a continuous source of acidic and SO4- and metal(loid)s-rich leachates (resulting from the oxidation of sulfide minerals with water and oxygen), which pose serious threats to the surrounding ecosystems. In the laboratory, industrial waste has been added to the Tharsis mining soil to neutralize the acidity and immobilize the contaminants released from the mining soil following interaction with water. For this purpose, batch experiments were carried out using contaminated mining soil (60% by weight) mixed with different proportions of waste amendments (40% by weight). The following combination (by weight) of wastes were used: biomass ash (BA) and fish waste (FW) individually; BA+FW (1:3); BA+FW (2:2); and BA+FW (3:1). Milli-Q water was then added at a solid-to-liquid ratio of 1:10, followed by 24 h of shaking. The application of an alkaline amendment (100% biomass ash) to the mining soil neutralized the acidity of the leachates resulting from the interaction between the soil and water, increasing the pH from close to 3 to around 12. This sharp increases in pH achieved removal percentages of around 93-100% for Fe, Al, Mn, Cu, Zn, Ni and Co. Regarding SO4, the elimination rate of the solution reached a value close to 68%. On the other hand, the addition of an amendment composed exclusively of fish waste to the soil increased the pH of the leachate to around 5. Despite the slight pH rise, the amendment achieved the total elimination of Fe, Al and Zn, and around 78-86% removal of Mn, Co, Ni and Cu. According to PHREEQC code calculations, the precipitation of phosphate phases (i.e., hydroxyapatite (Ca5(PO4)3OH) and/or MnHPO4) may have controlled the solubility of pollutants in the leachates generated from the amended soil. The chemical composition of the leachate from the mining soil remediated with biomass ash was within the limits established by the irrigation (Food and Agriculture Organization of the United Nations (FAO)) and drinking (World Health Organization (WHO)) waters standards. This study demonstrates that biomass ash and fish waste are effective amendments to remove metal(loid)s from leachates of mining soils. However, further larger-scale experiments are required to assess the long-term effectiveness of these amendments and their influence on soil properties.

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GT 11 - 993 - P

ECOTOXICOLOGICAL ASSESSMENT OF SOILS FROM A SALT MARSH AFFECTED BY SMELTER WASTES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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This study evaluates the ecotoxicity of sediments from the supratidal zone of San Antonio Bay (Argentina), a coastal area historically impacted by lead smelting wastes. Three sites were sampled: two corresponding to smelter slag dumps, and a third, unaffected site with similar geomorphological features. Sediments were collected from depths of 50–100 cm and 200–250 cm at the affected sites, and from 50–100 cm and 150–200 cm at the unaffected site. Main physico-chemical properties were analyzed in triplicate, including pH, electrical conductivity (EC), total organic carbon (TOC), carbonate content (% as CaCO3 equivalents), cation exchange capacity (CEC), and texture. Soluble concentrations of elements (Al, Ca, K, Na, Mg, Fe, Mn, S, Cd, Cu, Pb, Zn) were determined by water extraction at a solid-to-liquid ratio of 1:5 (m:V) and subsequent analysis using ICP-OES. Metals with the highest solubility were identified in the following order: Zn (up to 545 mg/L) > Cu (up to 19 mg/L) > Cd (up to 2.8 mg/L) > Pb (up to 2.4 mg/L). According to WHO guidelines for chemical contaminants in drinking water, 17% of the polluted samples exceeded the threshold value for Cu, while 100% exceeded the limits for Cd and Pb. Phytotoxicity was assessed through seed germination and root elongation bioassays with Lactuca sativa L.; the water-extractable fraction of each sample was tested in triplicate, and results were expressed as root elongation reduction (RootRed) (%) relative to control. The germination percentages did not vary significantly ($p > 0.05$) between the control and the samples. However, root elongation was significantly inhibited ($p < 0.05$) in the impacted sediments, with reductions reaching up to 93.5%. Meanwhile, in the unaffected samples the water extracts induced hormetic stimulation in root growth, with mean root length exceeding the control. Principal Component Analysis (PCA) grouped variables into two main components explaining 80.3% of the total variance (PC1: 54.5%; PC2: 25.8%). RootRed was positively associated with PC2, alongside soluble concentrations of Pb, Zn, Cu, and Cd, and inversely associated with pH and carbonate content, suggesting a protective effect of these last two variables. Variables such as S, EC, Na, clay, CEC, and TOC were more strongly associated with PC1. These results highlight the high phytotoxicity of smelter-impacted sediments, driven primarily by soluble heavy metals and secondly by salinity-related ions. The integration of bioassays with chemical data proves essential for evaluating ecological risk in contaminated sediments.

KEYWORDS

Smelter pollution, heavy metals, bioassay.

GT 11 - 994 - P

DEGRADATION AND RENATURALIZATION OF SOILS AFFECTED BY TOURIST ACTIVITY IN THE BIESZCZADY MOUNTAINS (SOUTH EAST POLAND)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Hiking, biking, and horse riding are increasingly popular forms of tourism in mountainous and protected areas, contributing to growing pressure on natural environments (1). Numerous studies have documented the negative impacts of such activities, particularly soil degradation and vegetation loss along tourist trails (2, 3, 4, 5). While extensive research has been conducted in regions like the U.S., Australia, and parts of Europe, there is a lack of detailed studies focusing on soil degradation and renaturalization in mid-altitude mountain ranges with sedimentary rock and moderately humid climates. Moreover, few works analyze the entire soil profile or assess long-term natural recovery of degraded soils. This study aimed to assess the extent of soil degradation caused by hikers along tourist trails in broad-leaved forests and subalpine meadows of the Bieszczady Mountains (southeastern Poland), using the full thickness of the soil profile, as well as to evaluate the direction and rate of soil renaturalization over varying time spans. Seven out of 25 representative plots were selected for detailed analysis. On each plot, three types of research sites were identified perpendicular to the trail: (a) type R – soil within fenced, regenerating areas; (b) type T – soil currently located on active tourist trails; and (c) type N – undisturbed, natural soil with no signs of trampling. Tourist activity led to significant soil degradation, including soil compaction and profile truncation, with erosion depths reaching up to approximately 0.5 meters. Surface stone layers (“posterosional pavement”) were found to mitigate further erosion. While freeze–thaw processes and needle-ice formation contribute relatively quickly to soil loosening, the development of a new topsoil (A horizon) is much slower. However, the humid climate and loamy soils rich in organic matter and with high cation exchange capacity support relatively rapid vegetation regrowth, aiding in erosion control.

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GT 11 - 995 - P

ENVIRONMENTAL IMPACT OF DEMINING ON SOIL CONTAMINATION: CASE STUDY FROM MYKOLAIV REGION, UKRAINE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Ukraine is experiencing the highest levels of landmine and Unexploded Ordnance contamination globally, limiting agricultural activity on about 30% of its territory [1]. Although intended to restore access, mine clearance can cause secondary contamination by releasing potentially toxic elements (PTEs), explosive residues, and other toxic pollutants into soils and groundwater.

This study focuses on evaluating the extent and nature of soil contamination associated with different demining methods: manual demining, in-situ detonation, and mined land rehabilitation. In a field study, 50 soil samples were collected from the Pervomaisk community in the Mykolaiv region, occupied in 2023. Samples were analysed for pH, electrical conductivity, and more than ten PTEs. Prior to sampling, we reviewed factors contributing to military and anthropogenic pollution and assessed pollutant composition from demining activities. Pearson's correlation coefficient and principal component analysis were used to evaluate the data.

The Kruskal–Wallis test revealed statistically significant differences in concentrations of aluminium (Al), barium (Ba), chromium (Cr), copper (Cu), and manganese (Mn) across mined areas, manually demined areas, and sites with in-situ detonation ($p < 0.05$). Specifically, on-site detonation was linked to increased Ba, Cr, and Cu levels, while manual demining was associated with elevated Al, Ba, Cr, Cu, Mn, and Fe. No significant differences were found for B, Co, Ni, and P across site types.

These findings emphasize the issue of secondary contamination from demining and the importance of systematic soil quality assessment tools. Such tools are essential to ensure that land released for agriculture is truly safe and does not pose long-term risks to food security, ecosystem health, or human well-being.

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GT 11 - 996 - P

PREVENTING ACID MINE DRAINAGE USING ARTIFICIAL SOILS: A PILOT MINE WASTE DUMP CLOSURE PROJECT IN THE IBERIAN PYRITE BELT (THARSIS MINE, HUELVA)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The total land area affected by mining activities and waste storage has been estimated as 400,000 km2 [1]. In sulfide mining, this vast area presents two main impacts: firstly, these surfaces behave as a source of acidic leachates with high concentrations of sulfates and metal(loid)s, known as acid mine drainage (AMD); secondly, it constitutes a loss of land surface. The mine waste dumps are an example of these environmental concerns, making it necessary and urgent to design solutions to address this challenge. An extraordinary example of an extensive territory affected by the mining industry is the Iberian Pyrite Belt (IPB), which is located southwest of the Iberian Peninsula and contains one of the largest deposits of massive sulfides in the world. An estimated 200 million m3 of waste is found in the IPB [2] . This study evaluates a pilot-scale experience (300 m² plot) involving the use of an artificial soil (Technosol) applied to a mine waste dump at the Tharsis mine (IPB, Huelva). The application of the Technosol aims to prevent the formation of AMD and to improve some physicochemical properties of the mine dump material. For that purpose, three layers of artificial soil were made with local wastes. One layer was applied directly on the mine waste to promote the chemical stabilization of the sulfides and stop its oxidation. Above the previous layer, a new one to limit oxygen infiltration. Finally, a superficial layer rich in nutrients to promote the growth of vegetation. The results show an increase in the pH of the leachate and a significant reduction in metal(loid)s concentrations, demonstrating the effectiveness of this technology in preventing AMD. Moreover, the application of the Technosol improved the properties of the dump material, increasing its pH, CaCO3 content, Cation Exchange Capacity (CEC), and decreasing the concentration of metal(oid)s. However, ongoing monitoring of the leachate and mine waste material is required to confirm the long-term effectiveness of this promising solution.

ACKNOWLEDGEMENTS

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GT 11 - 1021 - P

EFFECT OF TRACE METAL CO-CONTAMINATION ON AMOXICILLIN MOBILITY IN SOILS FROM GALICIA (NW SPAIN)

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Antibiotics are crucial for treating infectious diseases in humans, plants, and animals. However, their massive use over recent decades has led to their detection in water bodies, agricultural soils and even in crops. Up to 90% of the ingested amount of antibiotics is excreted from the organism, accumulating in manures, slurries or sewage sludge from wastewater treatment plants (WWTP), which are often applied to crops as fertilizers without ensuring the elimination of antibiotics. The main risks include ecotoxicity, the proliferation of resistant bacteria and their incorporation into the food chain.

These pharmaceutical compounds often co-occur with other contaminants, such as copper, used as a fungicide in greenhouses and vineyards, and arsenic, present in feed animal additives and herbicides. Once in the soil, these compounds may undergo degradation, leaching or adsorption, which would prevent their transfer to water sources and plants. However, these processes depend on both the physicochemical properties of the soil and the antibiotic.

Consequently, this study investigated the adsorption capacity of six Galician soils, differing in pH (4.68-8.02) and organic matter content (3.06-12.32%), for the antibiotic amoxicillin. Adsorption was assessed in single (amoxicillin only) and binary (amoxicillin + Cu or As) systems via batch experiments using increasing contaminant concentrations (0–600 μmol·L^{-1}).

Amoxicillin adsorption in the soils varied with the added concentration of contaminants. In the single system, adsorption percentages were high at low concentrations (65–96%) and declined at higher doses (30–60%). At low concentrations, AMX adsorption in binary systems is reduced compared to the single system (<20%), suggesting competitive interactions favoring trace elements. In contrast, at higher concentrations, trace elements enhance AMX adsorption synergistically (60-95%). At the pH range of these soils, amoxicillin exists mainly as a zwitterion. Thus, copper may act as a cationic bridge between the negative charges of both the amoxicillin and the soil surfaces. Additionally, electrostatic attractions between the positive charges of amoxicillin and the negative charges of the soil, as well as the formation of copper–amoxicillin complexes, may occur. Arsenic, an anion, may enhance sorption by interacting with positively charged sites on amoxicillin and soil colloids. Moreover, arsenic might use calcium as a cationic bridge to bind both to the soil and the antibiotic. Desorption was higher in binary systems at low concentrations, but declined as concentrations increased, consistent with a cooperative adsorption mechanism.

ACKNOWLEDGEMENTS

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GT 11 - 1026 - P

CADMIUM FRACTIONATION AND TRANSFER IN CACAO-GROWING SOILS OF PANAMA

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Cadmium is a toxic element whose accumulation in cacao beans poses a concern for producing countries, such as Panama. The behavior of Cd in soils is influenced by factors such as pH, redox potential, and soil colloids, which determine its availability. This study aimed to assess the geochemical distribution of Cd in soil fractions through sequential extraction and its relationship with Cd accumulation in cacao plant tissues across five Panamanian production zones (Changuinola, Valle de Riscó, Intermedia, Insular area, and Ngäbe-Buglé region). A total of 68 soil samples were analyzed for general parameters and subjected to a sequential extraction procedure to isolate Cd into the following fractions: soluble, exchangeable, associated with non-crystalline Al, Mn, and Fe oxides, with crystalline oxides, with organic matter, and residual. In parallel, Cd concentrations were measured in cacao leaves, pods, husks, and beans. Pearson correlation analyses were conducted to explore relationships between soil Cd fractions and accumulation in plant organs. Results showed that Cd was predominantly found in the residual fraction (34–66%) and bound to non-crystalline oxides (21-31%), followed by associations with crystalline oxides (5-16%) and organic matter (2-10%). Exchangeable and soluble Cd represented the smallest proportions (2-5% and 1-4%, respectively), indicating limited immediate availability. Across all study zones, significant correlations ($p < 0.05$) were observed between Cd in the exchangeable and non-crystalline oxide fractions and Cd in plant tissues, particularly in beans ($r = 0.70$ and 0.71, respectively), suggesting these are the most bioavailable pools. Soil-to-plant transfer factors exceeded 1 in all zones, indicating a notable potential for Cd translocation into cacao tissues. Although Cd in Panamanian soils is predominantly present in inmobile fractions, the cacao plant absorbs this element from the more labile fractions and accumulates it in various organs. Given the cacao plant’s capacity to bioaccumulate Cd, these results offer key insights for the development of soil and crop management strategies aimed at minimizing Cd transfer to beans, thereby supporting sustainable production and adherence to international food safety standards.

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GT 11 - 1029 - P

BIOREMEDIATION EFFICIENCY IN SOILS CONTAMINATED WITH XYLENE AFTER FOREST FIRES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Soil is an essential and non-renewable natural resource. Forest fires cause severe changes to the physical, chemical and biological properties of soils, putting at risk their capacity for regeneration and increasing their vulnerability to chemical contamination [1]. In this study, xylene, a volatile compound used industrially and present in petroleum compounds, was used as soil contaminant. Aggravating the scenario, xylene high volatility, mobility and bioaccumulation capacity represent serious environmental and human health risks [2]. This study evaluated the effectiveness of bioremediation, via bioaugmentation and biostimulation, in burnt and unburnt soils contaminated with xylene. Microbial consortia from a former oil refinery were used, adapted to the contaminant. Bioremediation tests took place over 62 days under controlled laboratory conditions. The efficiency of xylene removal was evaluated by the concentration of xylene in the gas phase, the concentration of total petroleum hydrocarbons in the soil, the evolution of microbial biomass and the content of total organic carbon. The results showed removal rates of xylene in the gas phase of 91% in burnt soils and 90% in non-burnt soils, and the analysis of TPH removal in the soil was substantially higher in the non-burnt soil at around 89% compared to the burnt soil (47%). In order to assess the degradation of xylene over time, the Total Organic Carbon (TOC) was analysed to see if the organic carbon present in the soil (xylene) was being transformed into inorganic carbon. It was found that the unburnt soil had an 18% conversion of the contaminant present in the soil, unlike the burnt soil which had a 35% removal. The microbial biomass showed two different profiles, with faster activity in the burnt soil, with a growth peak on the seventh day, while in the burnt soil this occurred on the 21st day. It can be concluded that bioremediation remains viable even in post-fire soil scenarios, but that it is necessary to adjust strategies to the altered soil conditions.

KEYWORDS

Soils,bioremediation, bioaugmentation, biostimulation, forest fires, xylene.

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GT 11 - 1030 - P

HEAVY METAL TRANSFER FROM GOLD MINE DUMP TO SOILS AND CROPS IN MOZAMBIQUE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Mining activities in Mozambique have contributed to national economic and social development. However, environmental impacts from abandoned mines remain a concern. This study investigates heavy metal contamination in the waste dump of the abandoned Penhalonga gold mine (Manica Province) and in agricultural soils and crops located at distances of 0.5, 1, 1.5, 3, and 6 km from the mine. The aim is to assess the distribution and mobility of heavy metals in soils and their accumulation in crops cultivated in the surrounding areas. Soil samples were collected from two depths (0–20 cm and 20–40 cm) in various sectors of the waste dump (Center, CE; North, N; South, S; East, E; West, W) and from agricultural plots. Predominant crops in each area were also sampled. In all soil and waste dump samples, total, available, and exchangeable concentrations of Cu, Zn, Cr, Ni, Cd, Pb, and Hg were determined. These elements were also analyzed in the roots, stems, and leaves of the sampled crops. Chromium was detected at significantly higher concentrations than other metals ($p < 0.05$), with the following abundance trend: Cr > Ni > Hg > Pb > Zn > Cu > Cd. In plant tissues, Cu, Cr, Ni and Pb showed the highest concentrations in crops located 3 km from the mine, particularly in the roots. Zn levels were elevated in crops from both the mine center (CE) and the area 6 km away, mainly in roots and stems. Mercury levels were highest in crops growing between 0.5 and 1 km from the mine, with accumulation primarily in roots and stems. The absence of mine dump environmental restoration has left soils degraded and contaminated, posing a risk to communities engaged in agriculture in these zones. Heavy metals persist in the environment, bioaccumulate in plant tissues, and may enter the food chain. Based on international safety thresholds for plant tissues, the greatest risks are associated with plants grown within the mine site and in cultivated areas with elevated Zn, Cr, and Hg levels. All crops analyzed showed excessive Cr accumulation in roots, stems, and leaves within the mine and in areas from 1.5 to 6 km away. Elevated Hg concentrations were observed in crops between 0.5 and 1.5 km, especially in roots and stems. Cu, Ni, and Pb were also detected at concerning levels in stems from crops grown outside the mine area. The results highlight the long-term environmental impact of abandoned mining activities and the urgent need for monitoring and remediation. Contaminated soils near the abandoned Penhalonga gold mine continue to pose a significant risk to agriculture and food safety. Mitigation strategies are needed to reduce metal mobility, limit plant uptake, and protect community health

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GT 11 - 1031 - P

INFLUENCE OF MICROBIAL ACTIVITY ON THE MOBILITY OF POLLUTANTS IN EL BUITRE MINE TAILINGS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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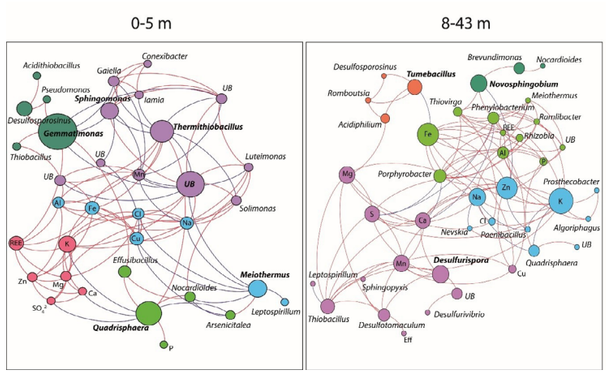
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El Buitre Mine tailings deposit in Copiapó, Chile, has been closed for 20 years. Until then, several mines brought copper ore that would be processed through alkaline flotation, whose slurry were accumulated in this deposit. To characterize the deposit, 755 m of core samples from 24 drills of up to 43 m deep were geochemical and microbiologically analysed. The aim of this study was to assess the level of pollution and the role of the microorganisms in the mobilization of pollutants from the surface to the bottom. Paste pH, potential toxic elements bioavailability, microbial biodiversity and bioinformatic tolls were used for the biogeochemical characterization of the tailings.

The chemical analysis of the soluble fraction of the core samples, targeted metagenomics sequencing, and network analysis have shown two well-defined geochemical zones: oxidized zone (from surface down to 5 m deep) and non-oxidized zone (from 8 to 43 m deep) with a particular bacterial enrichment in each zone of the tailing. According to the geochemistry of the soluble fraction, the oxidized zone (0-5m) was enriched on salts, mainly Ca, Na, Cl, and S (ANOVA test, $p < 0.05$), while the non-oxidized (8-43 m) zone was enriched in Fe, Al, and trace concentrations of Mn (ANOVA test, $p < 0.05$). The network analysis shows higher co-occurrence in the deepest zones, suggesting that the network in the non-oxidized zone is more resilient under stressful environmental conditions than the network in the oxidized zone. Unlike the non-oxidized zone, where more abundant positive correlations were found, the variable conditions (e.g., temperature and wind) in the oxidized zone might affect the structure of this network/community, constantly changing the bacterial composition, affecting the co-occurrence of the species and the efficiency of the network. The incorporations of environmental factors in the network analysis also suggest that the non-oxidative network is more efficient than the oxidative network. The inferred functionality shows phototrophs dominating the oxidized zone and chemolithotrophs in the non-oxidized zone, suggesting a metabolic specialization in the profile. In addition, the positive correlation between metals and bacteria in the deepest zones suggests more influence of these bacterial groups in the mobility of metals, which could have environmental implications for surface and groundwater. However, the confirmation of bacterial influence in the mobility of heavy metals and salts in alkaline tailings in both zones should be done by experimental studies to ensure that the interpretation of the omics data agrees with the empirical evidence.

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Networking Analysis

GT 11 - 1033 - P

ALGINATE–CMC–BIOCHAR–CLAY MICROSPHERES FOR EFFICIENT AND IRREVERSIBLE ADSORPTION OF THE IONOPHORE ANTIBIOTIC MONENSIN

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Monensin (MON), is a highly toxic ionophore antibiotic widely used to treat coccidiosis, a protozoan disease that causes many problems in livestock, mainly in poultry production. This compoud is considered a priority environmental pollutant due to its persistence in soils and water. This study focuses on the synthesis and evaluation of novel hydrogel microspheres composed of alginate (AL), carboxymethyl cellulose (CMC), biochar (BC), and non-swelling red Moroccan clay (NSW) for MON removal. Several formulations (AL, AL-CMC, NSW-AL, NSW-AL-BC, and NSW-AL-CMC) were developed and systematically analyzed using advanced characterization techniques. These include X-ray diffraction for crystallinity, FTIR for functional group analysis, and SEM for surface morphology. The adsorption/desorption tests were conducted to evaluate the capacity of the synthesized hydrogel microspheres to remove the ionophore antibiotic MON from aqueous solutions. In the adsorption phase, a known amount of hydrogel was immersed in MON-contaminated added water under controlled conditions (pH, temperature, contact time), and the amount of MON adsorbed was quantified using High performance liquid chromatography (HPLC) and analytical techniques. After equilibrium was reached, desorption tests were performed by placing the MON-loaded hydrogels in a clean solvent (water + CaCl2) to measure the release of the ionophore antibiotic. These tests help determine the adsorption efficiency and the reversibility of the process. The superior adsorption of NSW+AL+CMC (93.5% adsorption and 0% desorption) is due to the presence of CMC, which introduces additional carboxyl and hydroxyl groups, enhancing hydrogen bonding and electrostatic interactions with MON. The high illite (55%) content in NSW clay contributed significantly to the composite’s superior performance, despite the nature of illite having low cation exchange capacity, it plays a major role in polymer stabilization to produce stably and rigidly composed hydrogel microsphere. Conversely, NSW+AL (38.3% adsorption and 0% desorption) lacks of CMC extra functional groups, limiting its adsorption capacity. The correlation data confirms this trend, with adsorption closely associated with interstratified particle size D(nm) (0.73), CMC content (0.73), and illite particle size (0.71), explaining the improved retention in the CMC-modified composite. Adsorption data best fit the nonlinear Freundlich isotherm, confirming the material’s heterogeneous and multilayer adsorption behavior. Compared to Langmuir and Henrys which does not fit the adsorption data due to poor R2 < 90% and very large error. Computational investigations using Density Functional Theory (DFT), molecular electrostatic potential mapping, Mulliken charges, Monte Carlo simulations, and Hirshfeld surface analysis provided molecular insights into the adsorption mechanism. Key interactions involved O-H---H-C, C-H---O-Si, C-H---O-C, and C-O---H-C hydrogen bonds, which were enhanced by polymeric and biochar modifications. These physicochemical enhancements also affected surface parameters such as pH, Zeta potential (ZP), and crystalline indices, further improving adsorption efficiency. The irreversibility and high retention capacity of NSW-AL-CMC highlight its strong potential as a sustainable, low-cost, and eco-friendly material for the remediation of MON-contaminated environments. This research offers a promising route for integrating natural and modified clays with bio-based polymers to address antibiotic pollution, aligning with circular economy principles and advancing environmental and human health protection.

KEYWORDS

Clay, Monensin, Biochar, Carboxymethylcellulose, Alginate

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GT 11 - 1036 - P

EFFICACY OF FOURTEEN LOW-COST BIO-ADSORBENTS FOR THE REMOVAL OF LASALOCID FROM ENVIRONMENTAL COMPARTMENTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Recently, lasalocid (LAS) has emerged as one of the most frequently detected ionophores in the environment, with elevated concentrations reported either in aquatic systems (Bak and Björklund, 2014) or in soils (Sassaman and Lee, 2007), thereby threatening ecological and human health. In view of this, the current study assessed the capacity of fourteen low-cost bio-adsorbents (fibers, barks, and agro-food by-products) to adsorb LAS from aqueous solutions.

The main physicochemical properties of these bio-materials were determined using standard procedures, where the studied by-products presented varying pH levels (3.7–7.4), as well as a high organic matter contents (between 17% and 68.4 %) and eCEC values (ranging 8.55-26.7 cmolckg−1). Furthermore, infrared (FTIR) characterization was performed for the raw materials using a FTIR-Bomen MB102 spectrometer (ABB, Switzerland), revealing a distinctive composition to each by-product in terms of functional groups and chemical structure. The adsorption experimental setup consisted in performing batch tests, using 0.5 g of each by-product sample, to which the selected LAS concentrations (5, 10, 20, 40, 80, and 100 µmol·L^{-1}) were added, followed by the quantification of the antibiotic using and Ultimate 3000 HPLC-UV system (model LPG 3400 SD, Themo-Scientific, USC) equipped with Chromeleon software version 7 (Thermo Fisher Scientific, Madrid) . The results indicate that the biomaterials with pH values ranging from 4.5 to 5.5, including acacia and eucalyptus barks, alfa and palm fibers, orange peel, almond shell, and date palm stones, exhibited the highest adsorption capacities for LAS, consistently reaching values ≥ 96.3% regardless of the concentration added. This makes them of high interest for being used in LAS removal processes, thereby supporting their valorization and reuse. Regarding the other bio-adsorbents (except for cactus fiber), they could also be recommended for retaining LAS given their acceptable removal efficiency even at the highest added concentrations, with adsorption scores always ≥ 64.4 %). The Freundlich model proved the most suitable for describing LAS sorption data, indicative of heterogeneous surface interactions. Desorption percentages did not exceed 12% in any case, indicating a rather irreversible adsorption process. Promoting by-products recycling, while favoring the remediation/removal of antibiotics that have emerged as environmental contaminants, holds valuable relevance at the level of research and social implications.

KEYWORDS

Ionophore antibiotics, adsorption-desorption, lasalocid, by-products, ecosystems.

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GT 11 - 1037 - P

GROUND COVERS AND CLIMATE CHANGE: IMPACT ON THE SOIL-PLANT SYSTEM OF YOUNG VINES UNDER SEMI-CONTROLLED CONDITIONS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Viticulture in the Mediterranean region faces serious challenges from soil degradation caused by traditional agriculture, worsened by climate change, which threatens the sustainability of vineyards (Vitis vinifera L.) in semi-arid areas like central Spain. New vineyards, increasingly needed to adapt to climate change and market demands, are particularly vulnerable to soil erosion. Legume ground covers (GCs) between vine rows can reduce erosion, fix nitrogen, and improve soil health, helping young vines to establish and become more resilient. However, its success depends on water availability, the choice of legume species, and the vine variety, whose interactions, especially in the early stages of young vines, remain little explored.

The objective of this study was to evaluate the potential of two legume GCs to improve the establishment of a new vineyard plantation (two varieties) under two levels of water availability in the context of a simulated warming scenario (+2 °C). The experiment, carried out in mesocosms under semi-controlled greenhouse conditions (Madrid, Spain), followed a multifactorial design: three cover types (Medicago truncatula Gaertn., Trifolium subterraneum L., and bare soil), two water levels (moderate watering, and 15 % reduced), and two vine varieties, white and red (Airén and Tempranillo). The GCs were mowed 75 days after sowing and cut material was left on the surface as mulch. The effects of the factors and their interactions on selected physical, chemical, and biological properties of the soil, as well as on vine growth and nutritional status were evaluated at the end of the first growing cycle.

Results showed that soil and plant responses largely depended on interactions. Compared to bare soil, legume GCs improved infiltration, dissolved organic carbon, and microbial activity. Trifolium GC increased enzymatic activities (β-glucosidase, N-acetylglucosaminidase and urease), and microbial biomass carbon; Medicago GC increased basal respiration and phosphatase enzymatic activity. Water level mainly affected vine biomass and nutrient uptake: under water stress (-15%), GCs had neutral effects on vine growth; under moderate water level, GCs reduced aboveground biomass and foliar Ca, Mg, B, and Zn, but increased P uptake and promoted a favorable vegetative balance (root biomass/aboveground biomass), beneficial for young vines establishment. Promising combinations included Tempranillo–Trifolium and Airén–Medicago, though effects varied by parameter.

Overall, legume GCs improved soil health and regulated vine vigor under optimal water level without negative effects under water stress, supporting their role as sustainable tools for climate-resilient viticulture. Finally, it will be necessary to validate these results through extended field studies conducted under diverse edaphoclimatic conditions.

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GT 11 - 1043 - P

MICROFIBRES IN SOIL: DEGRADATION IN SOIL ENVIRONMENTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Microfibre pollution is of growing global concern [1]. One of the main pathways of release into the environment is from textiles through laundering into rivers and waterways via waste-water treatment plants [2]. Microfibres also make their way into sewage sludge via these waste-water treatment plants [3]. This sewage sludge is then applied to agricultural land as fertiliser which introduces microfibres to terrestrial environments. Microfibres are often categorised as part of the microplastic problem, however, studies have shown that cotton microfibres are the most prevalent in the environment [4]. These non-plastic microfibres often have chemical dyes and finishes applied during manufacturing so pose a potential risk to soil environments.

This project investigates the impact of degrading plastic and non-plastic microfibres, dyed and undyed, on soil environments. An experiment has been set up with dyed and undyed swatches of cotton, wool, virgin polyester, recycled polyester from PET bottles and recycled polyester from plastic sea waste. These have been buried in soil in glass petri dishes and will be monitored over 18 months using pyrolysis-GC-MS and LC-MS to trace chemical changes to the soil and fabric over time, as well as monitoring impacts of fibre degradation to soil properties and soil function.

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GT 11 - 1045 - P

QUANTIFICATION OF FLUORESCENT MICROPLASTICS (≤ 2 MM) IN SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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The environmental behaviour and risk of microplastics (MP) are strongly size-dependent, with growing concern over small MP (≤10 µm). To enable effective identification, tracking, and localization, MP are generally fluorescently labelled prior to analysis. However, the optimal quantification of fluorescently labelled MP (≤10 µm) in soil remains unknown. We evaluated three methods—no separation (direct detection), magnetic separation, and density separation—for quantifying 2 µm fluorescent MP at 0.01% and 0.001% w/w concentrations in loamy sand. Direct detection was the most time-efficient, and yielded recovery rates (based on fluorescence area ratio) of 49.1 ± 9.3% and 53.1 ± 10.9%, as compared to recoveries of 60.4 ± 5.0% and 61.7 ±3.16% with magnetic separation. Density separation resulted in the lowest recovery rates of 7.5 ± 2.3% and 6.8 ± 0.8%, respectively. We then systematically optimized the direct detection method across 11 concentrations (0.1% to 0.000001% w/w) and applied it to different soil types. The results indicated that a single subsample at each concentration, coupled with the analysis of 30 images per filter, was sufficient to establish a strong positive correlation between fluorescence area and MP concentration ($r = 0.993$, $p < 0.001$). The detection limit was as low as 0.000001% w/w (i.e. 0.01 ppm) for the direct detection method. The fluorescence area and intensity of MP were influenced by soil type, but a strong correlation between fluorescence area and MP concentration remains. This study established a methodological framework for the quantification of MP (≤10 µm) under varying requirements for analytical efficiency and accuracy.

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GT 11 - 1047 - P

ORGANO-MINERAL AMENDMENTS MODULATE NUTRIENT DYNAMICS AND METAL UPTAKE IN MAIZE IN CO-CONTAMINATED SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Heavy metals (HMs) pollution in agricultural land has become a major environmental concern due to rapid urbanization, industrialization, mining and improper agrochemicals use. HMs not only effects the soil health, plant physiology but also hazardous for human's health and ecosystem stability. This experiment was designed to evaluate the effect of biochar and inorganic amendments in sole or in combination form to alleviating the toxicity of Pb and Zn in maize. The soil samples were contaminated artificially with 2 levels of lead (Pb) and zinc (Zn) and incubate for 40 days at 60% WHC. After incubation, the maize plants were grown in co-contaminated soil with the sole and combined application of biochar and inorganic amendments. After harvesting, growth and physiological parameters, antioxidant enzymes and ionic attributes were determined. The results showed that application of biochar and inorganic amendments alone and in combine form mitigated Pb and Zn toxicity in maize crop and enhanced physicochemical parameters. While the combined application of biochar and inorganic amendments prominently reduced Pb and Zn toxicity in root and shoot as compared to sole application of biochar and inorganic amendments. Combined applications of organo-mineral amendments not only significantly reduced the different soil Pb and Zn fractions and their available concentrations but also prominently enhanced antioxidant enzyme activities in heavy metals contaminated plants. Further, it was concluded that combined application of biochar and inorganic amendments played a significantly role to improve the biochemical and ionic attributes and also enhanced the plant growth by alleviating the toxic effect of Pb and Zn in co-contaminated soil. The findings of this research suggested that synergistic use of biochar and inorganic amendments could be a highly effective remediation strategy for reducing HMs uptake in plants and immobilization in co-contaminated soil.

GT 11 - 1061 - P

ADSORPTION AND DEGRADATION OF DIMETHENAMID-P, MESOTRIONE AND RIMSULFURON IN AN AGRICULTURAL SOIL UNDER CONSERVATION PRACTICES

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 07. SOIL AMENDMENTS & FERTILIZERS

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Conservation agriculture practices, including organic amendments and mulching, increase soil organic carbon content and improve soil structure, stability and biodiversity, among other benefits. These changes in soil properties control the behaviour of herbicides in the soil and their persistence could be modified when applied under these agricultural practices. This work studied the impact that i) green compost (GC) and ii) mulching practice applied to a sandy loam soil (control) have on the environmental fate of the herbicides dimethenamid-P, mesotrione and rimsulfuron from the evaluation of their adsorption and degradation under laboratory conditions. Formation and degradation of major metabolites of the herbicides were determined. GC was applied to the topsoil (~5 t C/ha), while wheat residues were disposed as a mulch layer covering ~50% of the soil surface in the 6-year-old mulching treatment. Adsorption (distribution coefficients, Kd), and degradation (half-life, DT50) parameters were determined for topsoil samples from the batch equilibrium technique and soil incubation under aerobic conditions in the dark over 55 days, respectively. Mass balance of 14C-mesotrione (mineralized, extractable and non-extractable fractions) was also determined for the different soil treatments over 55 days. Adsorption capacity of herbicides followed the order mesotrione < rimsulfuron < dimethenamid-P with the GC treatment showing the highest Kd values. The degradation DT50 values followed the order dimethenamid-P < mesotrione < rimsulfuron in the different soils studied with the GC treatment showing the highest DT50 values. The application of GC slowed down the rate of herbicide degradation and increased their persistence in the soil due to greater adsorption and lower bioavailability of the herbicides to be degraded. The effect of the conservation practice on the DT50 differed depending on the herbicide, being greater for the degradation of rimsulfuron, with higher DT50 values in the soil amended with GC or mulch compared to the control soil. The use of GC or mulch increased the persistence of the three herbicides in the soil (1.4 times for dimethenamid-P and mesotrione, and 1.9 times for rimsulfuron). For 14C-mesotrione, mineralization was lower in soils with GC or mulch than in the control soil. A major percentage of water extractable 14C residues was detected in soil+mulch, indicating a higher bioavailability of mesotrione and its metabolites to be degraded. The fraction of non-extractable 14C residues was similar for all the treatments. The difference in degradation rates and variability in response to the conservation practice indicate that the physicochemical properties of herbicides are crucial in determining its interaction with GC or mulch and its fate in the soil.

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GT 11 - 1065 - P

A UNIQUE PETROLEUM EXPLOITATION IN SPAIN: STRATEGIES FOR SOIL RECOVERY THROUGH INDUSTRIAL CROPS AND BIOTECHNOLOGY

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 04. SOIL BIOLOGY

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The pHYBi project (Phytomanagement for the sustainable production of high-value lignocellulosic raw materials for the textile sector) promotes the use of marginal or contaminated soils to generate plant biomass for sustainable textile applications. Using non-food industrial crops such as miscanthus, hemp, poplar, willow and birch, pHYBi is developing phytoremediation strategies adapted to different contamination types, integrating precision agriculture, beneficial microorganisms and organic amendments. One case study is located in Sargentes de la Lora (Burgos, Spain), site of the only onshore petroleum field ever commercially exploited in Spain (closed in 2017). The area includes both active farmland and degraded plots. Industrial crops have been identified as a suitable phytomanagement solution to recover soil health and enhance the local bioeconomy.

Several sampling campaigns assessed the pollution status. Analytical results revealed that total petroleum hydrocarbons (TPH) in some areas reach up to 15,000 mg/kg, including various aliphatic compounds. Multispectral images were acquired with an unmanned aerial vehicle to develop detection models for these pollutants through remote sensing. Controlled greenhouse experiments are underway using polluted soils from the site at three TPH concentrations (1,000, 5,000 and 15,000 mg/kg) to evaluate the phytoremediation potential of Miscanthus × giganteus and Cannabis sativa. At the same time, native endophytic and rhizospheric microorganisms with potential for contaminant degradation and plant growth promotion are being isolated. These microorganisms will be applied as inoculants in combined bioremediation trials with miscanthus and hemp in contaminated plots, closing the cycle of soil recovery and sustainable raw material production for the textile industry.

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GT 11 - 1081 - P

IMPACT OF BIOCHAR AMENDMENT ON THE SPONGE FUNCTION OF BARE AND VEGETATED SOIL IN LONG-TERM LYSIMETER EXPERIMENTS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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Soil erosion by water poses major environmental challenges to the European viticulture sector. Biochar is recognised as a sustainable tool for combating land degradation, but few studies have been conducted in Mediterranean vineyards with hilly terrain and heavy rainfall. This study assesses the potential of biochar to support soil conservation by enhancing sponge function, i.e. water retention and infiltration, and reducing erodibility in sloping sandy loam soil under natural rainfall conditions. An 18-month outdoor box lysimeter experiment was conducted using bare soil, including soil amended with 4% (w/w) biochar from a Portuguese vineyard. In the bare soil study, biochar application significantly ($p < 0.001$) reduced the runoff coefficient by an average of 45%. Biochar reduced coarse fragment erosion by 67%, fine-earth erosion by 43%, and splash erosion by 34%, all affected ($p < 0.05$) by rainfall intensity. The erosion rate in vineyard soil was 3 times lower ($p < 0.001$) in biochar-amended than in control (3.7 vs. 11.1 t ha $^{-1}$ yr $^{-1}$). Improved soil structure led to a 7% reduction in bulk density, an average increase of 73% in stored water, and a 28% increase in infiltration rate. During drier periods, the biochar-amended soil stored 171% to 303% more water than the control soil. In the vegetated lysimeter study, sown with a biodiverse pasture seed mixture, biochar reduced runoff and soil erosion (fine earth fragment) by 50 % and 58 %. There was an improvement in soil physical and hydrological properties, i.e. bulk density decreased by 13.1 %, enhancing soil sponge function involving increasing water infiltration and soil water content by 50 % and 59 %. We recommend a minimum monitoring period of a full hydrological cycle under natural rainfall to comprehensively capture the effect of biochar on the soil sponge function. Observed seasonal trends and atmospheric river (AR) events suggest that studies using rainfall simulations without considering antecedent soil moisture and AR variations will yield skewed data on effects.

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GT 11 - 1086 - P

IMPACT OF THE PRESENCE OF MICROPLASTICS ON THE ADSORPTION-DESORPTION BEHAVIOUR OF THE HERBICIDE 14C-MESOTRIONE IN AGRICULTURAL SOIL

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The presence of microplastics in agricultural soils has gained an increasing attention over the last years due to their widespread prevalence. Microplastics may interact with other organic contaminants present in agricultural soils, such as pesticides, pharmaceuticals, etc., affecting their fate, distribution, and bioavailability. Nevertheless, just a few studies have focused on the interaction between microplastics and other organic contaminants in agricultural soils and its impact on the adsorption-desorption behaviour of organic contaminants, a key process that affects the mobility of organic contaminants in soil. In this study, a batch experiment was conducted to assess the effect of two types of microplastics, polyethylene (PE) (a conventional plastic) and polylactic acid (PLA) (a biodegradable plastic), on the adsorption-desorption behaviour of the herbicide 14C-mesotrione by a sandy loam soil. Adsorption experiments were performed with three treatments, namely soil, soil + 1% PE microplastics, and soil + 1% PLA microplastics. An aqueous solution (10 mL) of 14C-mesotrione was added to each treatment. For adsorption kinetics experiments, a 1 mg/L solution of 14C-mesotrione was used and samples were collected at 0, 0.5, 1, 2, 4, 8, 24, 48, 72 h. For the adsorption isotherms experiment, 14C-mesotrione solutions at initial concentrations of 0.5, 0.75, 1, 2, 5 mg/L were added to each treatment and an equilibrium time of 48 h was used. Samples were shaken in the darkness at 20 ºC. Desorption experiments were performed on the treatments treated with 5 mg/L of 14C-mesotrione solution, after isotherm experiments being concluded, by four sequential withdraw-replace steps. In each step, a 5 mL aliquot was taken from the solution and replaced by 5 mL of ultrapure water. The resuspended samples were shaken as indicated above, centrifuged and analysed. Adsorption kinetics and isotherms were analysed by liquid scintillation using a Beckman LS6500 liquid scintillation counter (Beckman Instruments Inc., CA, USA).

Results showed that the equilibrium between 14C-mesotrione and soil was reached after 48 h and that the presence of 1% of PE or PLA microplastics did not affect the equilibrium time. Adsorption isotherms fitted the Freundlich model for all treatments, showing R2 higher than 0.98. The Freundlich constants Kf and nf ranged from 0.22 to 0.25 (µg/g)/(mg/L)1/n, and from 0.87 to 0.90, respectively, for all treatments. The desorption coefficients (Kfd) of 14C-mesotrione were similar in all treatments (0.57-0.64 (µg/g)/(mg/L)1/n). Overall, the presence of PE or PLA microplastics in the agricultural soil did not affect the adsorption-desorption behaviour of the herbicide 14C-mesotrione.

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GT 11 - 1095 - P

PERVASIVE SOIL DISTURBANCE FROM UNMANAGED ROAD SEDIMENTATION IN A PROTECTED RAINFOREST OF SOUTHERN CHILE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 05. SOIL HYDROLOGY & EROSION

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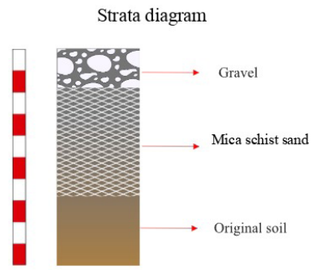
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Road construction in protected areas can be a major environmental disturbance, causing irreversible long-term changes often difficult to quantify. In particular, sedimentation from road construction and maintenance can lead to severe alteration of watersheds and vegetation in rainy climates. However, in many protected areas, this disturbance has not been quantified or even managed. Here, we characterized and quantified for the first time the sedimentation process from road sediments in watersheds of a National Park in the rainforest region of southern Chile. The study area is Alerce Costero National Park (PNAC), which is crossed by a gravel road (T-800) constructed around 50 years ago that was stabilized with gravel a decade ago. We propose a method to characterize and spatially quantify sediment accumulation and its impact on soils in watersheds adjacent to PNAC road networks. Soils correspond to Inceptisols from the coastal mountain range (750–1,100 m a.s.l.), derived from mica schist metamorphic rocks. They are thin (40–50 cm), fine loamy-textured, classified as Oxic Dystrudepts. A prospective study was conducted in two micro-watersheds adjacent to T-800, with varying vegetation formations (among them, Alerce (Fitzroya cupressoides) forests and peatbogs). A grid with transects arranged parallel and perpendicular to the sedimentation vector was implemented. At a subset of points, sediment thickness (cm) was determined using a gouge auger. Co-located samples were taken to estimate sediment density, magnitude, temperature (°C), moisture (%), and bulk density of the original soil covered by sediment. The sedimentation rate was calculated. The original soil thickness averaged 30 cm, with bulk density 1.21 ± 0.3 g/cm³. Sediment can be transported up to 90–100 m from the gravel road, reaching a maximum thickness of 1 m. The first 75 cm of the soil profile corresponds to micaschist sand, followed by 10–20 cm of gravel. Sedimentation rates vary between 1.5 and 2.5 cm yr^{-1}, allowing accumulation up to 1000 m³, potentially increasing with local rainfall (4,250 mm/yr). The density of mica-schist sediment is 0.76 ± 0.27 g/cm³, and that of gravel is 1.33 ± 0.15 g/cm³. Areas with higher sediment have soil moisture of 10–15%, versus up to 30% in less sedimented zones, and temperatures of 12–16 °C compared to 8 °C. Further research is needed on factors affecting soil properties and their impact on the formation processes. The methodology is practical for quantifying the magnitude and characteristics of the affected area. Mica-schist sand and gravel are continuously transported from roads and accumulated in watersheds, potentially threatening rainforest ecosystems by altering edaphic variables. Incorporating additional factors (such as road length and slope, soil erodibility) is required to develop a more accurate model. Keywords: gravel, transects, fragile ecosystems, degradation.

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GT 11 - 1101 - P

EVALUATING SOIL HEALTH IN DEGRADED SITES THROUGH SOIL ORGANIC CARBON AND VISUAL SOIL ASSESSMENT

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Maintaining the functionality of soil ecosystems is a pressing concern in the context of climate change and increasing land use pressures. The PoLaRecCE Interreg project [1] is dedicated to developing sustainable strategies and innovative techniques for the restoration of degraded soil for non-food agricultural use. In this context, soil health in four pilot sites (Dél-Alföld and Békés in Hungary, Ormož in Slovenia, and Cairo Montenotte in Italy) across Central Europe, affected by different forms of degradation, were preliminary assessed through soil organic carbon (SOC) stock and Visual Soil Assessment (VSA)[2]. SOC stock was used as well-established indicator of soil health, while VSA was applied as an easy, on-site and proven method of assessing soil status through visual indicators, combining physical, biological and chemical properties. These indicators provide a useful approach to inferring relative differences in SOC through visual soil inspections. However, the relationship between SOC and VSA indices can depend on soil type, land use and management practices.

In each pilot site, soil samples were collected from soil profile (by horizon) and analysed. Additional 2–3 pits were sampled (by fixed depths;0–5, 5–10, 10–15, 15–20, 20–30, and 30–50 cm). In both soil profile and pit, soil condition was evaluated in situ using the VSA method, then the SOC stock was quantified.

The highest SOC stocks were found in the Hungarian sites of Dél-Alföld and Békés (78.94±16.28 and 128.17 ±39.96 Mg ha^{-1} respectively),the former affected by long-term poor agricultural farming practices and the later by urban pollution. The lowest values were recorded in Ormož (Slovenia), a site impacted by mining activities, with an average of 56.22±19.34 Mg C ha^{-1}.In Cairo Montenotte (Italy), affected by urban and industrial deposition of potential toxic elements, the mean SOC stock was 65.16±8.53 Mg ha^{-1}.The VSA indicated an overall moderate soil condition, but with strong differences among sites. The mean VSA was 30.6±0.2, 20.7±4.7, 23.3±4.9, and 24.3 ± 3.3, in Dél-Alföld, Békés,Ormož and Cairo Montenotte, respectively.

No linear relationship was found between SOC content and VSA indices as sites with high carbon stocks did not necessarily exhibit high VSA values. These results highlight the complexity of assessing soil health, showing that SOC content alone is insufficient for describing soil conditions across degraded sites. This suggests that other factors, such as soil type and land-use history, play a role beyond carbon quantity.

ACKNOWLEDGEMENTS

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GT 11 - 1106 - P

NATURE-BASED SOLUTIONS FOR SOIL QUALITY PROMOTION: CASE STUDY OF POTENTIALLY TOXIC ELEMENTS IN VINEYARD SOILS

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Concerns about copper (Cu) contamination are particularly pertinent in vineyard soils due to the high demand for phytosanitary treatments using fungicides containing this element. In addition to anthropogenic inputs, potentially toxic elements (PTEs) can also reach high levels due to the geological background. This is the case of arsenic (As) in some areas in the Douro Demarcated Region (DDR). This highlights the need for long-term solutions to alleviate these inputs to the soil while coping with naturally occurring PTEs, such as nature-based solutions like phytoremediation, which can be used on large areas as part of vineyard floor management.

Vineyards present unique challenges that require the development of tailored phytoremediation strategies. Implementing this approach predominantly involves dealing with poor soils (often anthrosols), extreme climatic conditions and drought, as well as considering different spatial scales, such as within or between the rows. Improving vineyard soil health under these limitations is relevant to the research questions of the SOILDIVINE Project, which focuses on whether vineyard floor management driven by nature-based solutions can meet soil health goals and, if so, how.

To explore the implementation of a phytoremediation strategy , an organically grown vineyard in the DDR was selected. As a first step, an assessment of various soil parameters that could model the mobilisation of Cu into plant tissues was made. Thus, soil samples were taken from different plots, and analyses were performed on the pH, organic carbon content, soil organic matter (SOM), texture, and the pseudo-total and available levels of Cu and other PTEs. Finally, a survey was carried out to identify the resident vegetation species already present in the vineyard, to allow the selection of the most relevant metallophyte species.

The pseudo-total Cu values quantified in these soils range from 35.2 to 133 mg/kg, and levels of As as high as 1957 mg/kg were observed, which could affect the implementation of the strategy. Soil pH values ranged between 5.36 and 6.97, and SOM varied from 2.38 % to 9 %. The higher Cu contents are correlated with lower pH values and SOM contents . On the other hand, As contents are positively correlated with pH. Higher plant species richness is associated with soils that are richer in SOM. The families represented by the greatest number of species were Fabaceae, Asteraceae and Poaceae.

All the data obtained support the design of a possible phytoremediation strategy and highlight the limitations that must be overcome to develop a feasible method that would help to achieve soil health while resorting to nature-based solutions.

ACKNOWLEDGEMENTS

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GT 11 - 1116 - P

BIOAVAILABILITY OF BENZO[A]ANTHRACENE IN BROCCOLI AND TOMATO GROWN IN CONTAMINATED SOIL AND GROWING MEDIUM

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 09. SOIL HEALTH

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Polycyclic aromatic hydrocarbons (PAHs) are toxic and persistent organic compounds in the environment due to poor solubility related to the number of condensed aromatic rings of which the molecule is composed [1]. The main sources of PAH are combustion processes and many industrial activities [2]. Plants and microorganisms are able to live in ecosystems containing these aromatic molecules [3]. In plants, the detection, transport, biotransformation of PAHs into less toxic compounds and their compartmentalisation are still unclear processes [3].

Therefore, the aim of this work was to determine the possible plant uptake of BaA, a molecule with four condensed aromatic rings, one of the 16 PAHs considered most toxic to human health, and chosen as a model PAH molecule, by food plants. For this purpose, the translocation capacity of BaA in broccoli (Brassica rapa) and tomato (Solanum lycopersicum) plants, grown both in contaminated soil (in vivo) and in contaminated substrate under axenic conditions (in vitro), was evaluated.

BaA phytotoxicity assays were carried out on both the plant species. Germination assays showed a reduction in the germination index in broccoli seeds in the presence of 50 and 100 mg kg-1 BaA and an increase in the germination index of tomato seeds as the BaA concentration increased.

The plant growth of both the species grown in BaA contaminated soil showed significant increases in biomass (d.w.) and the BaA detection occurred only in the tomato root systems (2% d.w.). No significant differences were found in the epigeal part of both the plant species compared to plants grown in uncontaminated soil (control).

To highlight the role of soil colloids in the bioavailability of BaA, broccoli and tomato plants were also cultivated in vitro using a contaminated nutrient medium. Under these conditions, a significant increase in plant biomass was found only in broccoli at the highest BaA concentration. The BaA concentration in the roots of both species was higher than that measured in the in vivo cultivation: in tomato roots, the BaA content was three times higher, while in broccoli roots the BaA concentration was, on average, twenty times higher than in plants grown in vivo. The increased bioavailability of BaA in the in vitro system was not followed by a BaA translocation into shoots and leaves of both plant species.

In conclusion, the contamination level of the studied plants was affected by interactions of BaA molecules on the soil matrix and was species-dependent. The higher bioavailability of BaA in the in vitro cultivation favoured its translocation within the plant, limited to the hypogeal apparatus. Thus, even at high contamination levels, a soil with appropriate physical and chemical characteristics is able to limit the mobility of BaA and thus its translocation into broccoli and tomato plants.

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GT 11 - 1132 - P

Potential of Pseudomonas extremaustralis CSW01 for paracetamol mineralization in soils with different properties

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Paracetamol (APAP) is an analgesic and antipyretic drug which is the most widely used in the world. It is frequently detected in agricultural soils, often originating from reclaimed wastewater used for irrigation and the application of biosolids often used as soil amendments. APAP and its metabolites accumulate in soils, with potential risks to soil organisms and plants.

The aim of this study was to study the abiotic and biotic mineralization of APAP in soils of different characteristics and to observe if bioaugmentation using certain microorganisms could be a promising approach for remediating APAP-contaminated soils. The novel bacterial strain Pseudomonas extremaustralis CSW01, isolated in our laboratory from sewage sludge produced in WWTPs, was used. It was capable of degrading and mineralizing very high concentrations of APAP in solution and adsorbed on sewage sludge.

Three soils with different physicochemical properties were used, in which APAP adsorption-desorption and mineralization studies were performed. Kinetic adsorption studies under abiotic conditions revealed that adsorption equilibrium in soils was very slow, not reaching a plateau even after 10 days. APAP desorption from soils after 10d adsorption experiments was totally null, and it was impossible to extract APAP from soils after finishing adsorption studies. Therefore, mineralization experiments using 14C-ring-labeled APAP in suspensions of the three soils under study were carried out, in order to observe if such rapid degradation results in the production of CO2 from APAP and/or from any of its metabolites. Soils were contaminated with 10 mg kg-1 APAP. The experiments were carried out in suspensions of 2g of contaminated soil and 20 ml of different solutions were added: (i) abiotic control, with NaN3 (200 mg L-1) added to avoid biological activity; (ii) biotic control, adding MSM medium to favour APAP biodegradation by endogenous soil microbiota; (iii) biotic degradation, adding MSM medium and bioaugmentation with the APAP-degrader strain P. extremaustralis CSW01. In the abiotic control, where biological activity was avoided, more than 6%, 10% and 15% APAP was mineralized in soils 1, 2 and 3 after 50 days of incubation, indicating that abiotic degradation that generates CO2 is taking place. The extent of IBP mineralization by the endogenous soil microflora of each soil increased till more than 18% for soil 1 and 20% for soils 2 and 3, which is in general accordance to values reported earlier. However, when P. extremaustralis CSW01 was inoculated, the percentages of APAP mineralized increased till more than 27%, 40% and 30% for soils 1, 2 and 3, respectively. These findings indicate that P. extremaustralis CSW01 is a very promising candidate for its use in APAP bioremediation in soils in order to avoid risks for off-site transport and/or plant accumulation of APAP and its transformation products and metabolites.



GT 11 - 1133 - P

EFFECT OF DIFFERENT TILLAGE SYSTEMS ON THE DYNAMICS OF ORGANIC MATTER IN COLOMBIAN ANDISOLS WITH A WARM CLIMATE

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 02. SOIL PHYSICAL CHEMISTRY

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Soil degradation is a major threat to agricultural sustainability, especially in the tropics, where intensive land use and poor mechanization practices accelerate the loss of soil organic matter (SOM), which is essential for maintaining soil structure, fertility, and water and nutrient retention capacity. The relationship between tillage systems and SOM dynamics was evaluated over two cropping cycles in a Typic Melanudands flatland (1050 m.a.s.l., 2150 mm*yr-1). Four systems were evaluated: no-till (L0), minimum tillage (MT), and conventional tillage (CT) with maize (Zea mays L.) and fallow land (FAR); Soil samples were collected in seven periods: before mechanization, and 0, 15, 30, 60, 90, and 120 days after planting, at depths of 0-10, 11-20, 21-30, and 31-50 cm, all in Horizon A. Soil organic carbon (SOC) was determined by Walkley-Black, and bulk density (BD), pH in water (2:1), and KCl (1N) were estimated. Texture was evaluated at the beginning and end.

Mean B.D. values were 1.11, 1.13, 1.15, and 1.18 g*cc-1 for LC, LM, L0, and Barb, respectively, increasing with depth to 1.20 g*cc-1 in L0 (30-50 cm). pH indicated values of 4.98, 5.12, 5.35 and 5.68 in LC, LM, L0 and Barb and exchangeable acidity of 4.50, 4.55, 4.78 and 5.30 for the same systems. This indicates that tillage contributes to increasing acidity in Andisols and that fallow soils show recovery in these properties (Fig 1). The SOC presented average values on the surface of 3.58%, 3.33%, 3.14% and 3.00% in LC, LM, L0 and Barb, with a tendency to reduce the contents in depth to 2.27%, 2.32%, 2.19% and 2.22% in the same systems respectively, which indicates that conventional tillage by mixing the horizon causes the SOC to tend to have higher contents in depth, but negatively affects properties such as the increase in acidity and apparent density of the soil.

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System	Depths	B.D.		pH Water (2:1)		pH KCL (1N)		SOC	
	cm.	g*cc^{-1}		pH Units				%	
Fallow Land	0 - 10	1,09	1,15 ab	5,99	5,68 a	5,40	5,30 a	3,00 a	2,53 a
	10 -20	1,19		5,72		5,04		2,54 b	
	20 -30	1,16		5,39		5,23		2,37 b	
	30 -50	1,16		5,64		5,51		2,22 b	
No Tillage	0 - 10	1,16	1,18 a	5,73	5,35 ab	4,91	4,78 b	3,14 a	2,56 a
	10 -20	1,19		5,12		4,73		2,58 b	
	20 -30	1,18		5,32		4,73		2,34 b	
	30 -50	1,20		5,22		4,75		2,19 b	
Minimum Tillage	0 - 10	1,06	1,13 ab	5,21	5,12 b	4,58	4,55 b	3,33 a	2,71 a
	10 -20	1,15		5,13		4,50		2,74 b	
	20 -30	1,14		5,02		4,55		2,45 b	
	30 -50	1,19		5,13		4,57		2,32 b	
Conventional Tillage	0 - 10	1,06	1,11 b	4,91	4,98 b	4,37	4,50 b	3,58 a	2,85 a
	10 -20	1,09		4,88		4,39		3,07 ab	
	20 -30	1,12		5,01		4,54		2,50 b	
	30 -50	1,15		5,13		4,69		2,27 b	

Fig. 1. Variation in average values of apparent density (BD), real and potential acidity and soil organic carbon in Colombian Andisols by different tillage systems.



GT 12. SOIL NATURAL HAZARDS FIRES, FLOODINGS, LANSLIDES

Communication formats

ORAL COMMUNICATIONS

FLASH+POSTER

POSTER



GT 12 - 116 - O

ASSESSMENT OF THE RESILIENCE OF MEDITERRANEAN SEMI-ARID SOILS TO LOW INTENSITY FIRES TO VALIDATE PRESCRIBED BURNING AS A WILDFIRE PREVENTION TOOL.

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Wildfires form part of the natural history of Mediterranean ecosystems, but in recent decades, their frequency and intensity have increased due to rural abandonment, accumulation of forest biomass, and climate change. This has led to a rise in large-scale fires, with serious consequences for soil and an increase in CO_2 emissions. In response, prescribed burns have emerged as an effective forest management tool, as they help reduce fuel loads and prevent severe wildfires. While widely used in other regions, their application in the European Mediterranean is uneven, especially in the semi-arid southeastern of the Iberian Peninsula, where soils are fragile. The general aim of this study was to evaluate the effects of prescribed burns on the physicochemical and biochemical properties of the soils of the range “Sierra de Gádor” (36º55’19”N 2º59’58” W), with a marl limestone lithology and vegetation dominated by Macrochloa tenacissima (L.) Kunth, in order to assess its resilience to disturbance and evaluate whether such burns could serve as a viable management tool in this semiarid area. On this study, several fertility-related parameters (pH, CE, conductivity, carbon, nitrogen, phosphorus) and key enzymatic activities involved in the biogeochemical cycles of carbon, nitrogen, and phosphorus were studied.

On December 12, 2024, the Andalusian Forest Firefighting Service (INFOCA) carried out a prescribed burn using the strip ignition technique, which consisted of manually burning the fuel in parallel lines to maximum spread, with a width between strips of 1-2 m. Three sampling plots of 10x10 m and separated by at least 100 m were established, and one month after the fire soil composite samples were sampled in each plot at two depths: 0-2 cm and 2-5 cm. In addition, a small area subjected to fire was allowed to develop a higher intensity burn to use it as a positive control area, taking soil samples at the same depths.

The results showed that fire mainly affected selected soil properties in the top 2 cm. Electrical conductivity increased due to higher salt content, especially after high-intensity fire. Similarly, Total organic carbon specially rose after high-intensity fire, likely from ash input, but not significantly due to the prescribed burning. Available phosphorus increased significantly in the top 2 cm in the prescribed and high-intensity fires. About enzymatic activities, dehydrogenase and phosphatase activities increased significantly after fire in both depths, from 0 to 5 cm. Urease activity remained stable after low-intensity fire but dropped notably after high-intensity in the first 2 cm.

As general conclusion, in the short-term low intensity fires only showed effects on soil properties in the top 2 cm, with only dehydrogenase affected up to 5 cm. High intensity fire showed clearly more important effects in soils.

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Location of study area

GT 12 - 271 - O

THE ROLE OF POST-FIRE SOIL EROSION IN THE CARBON CYCLE

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Wildland fires burn around 774 million hectares [1] and directly emit 2.1 Pg carbon (C) to the atmosphere annually [2]. The net effect of wildland fires on the C cycle, however, involves many interacting source and sink processes beyond these emissions from combustion. Among those, the role of enhanced soil organic C (SOC) erosion following wildland fires as a C sink mechanism remains essentially unquantified. Wildland fires can greatly enhance soil erosion due to the loss of protective vegetation cover and fire-induced changes to soil structure and wettability. Post-fire SOC erosion acts as a C sink when off-site burial and stabilization of C eroded after a fire, together with the on-site recovery of SOC content, exceed the C losses during its transport [3] (Figure 1). In this work we analyse published data on post-fire SOC erosion and assess its overall potential to act as C sink in the long-term. To determine its quantitative importance, we also model its magnitude at continental scale using the 2017 wildfire season in Europe. Our estimations show that the C sink ability of SOC water erosion during the first post-fire year could account for around 13% of the C emissions produced by European wildland fires. This indicates that post-fire SOC erosion is a quantitatively important process in the overall C balance of fires, and highlights the need for more field data to further validate this initial assessment.

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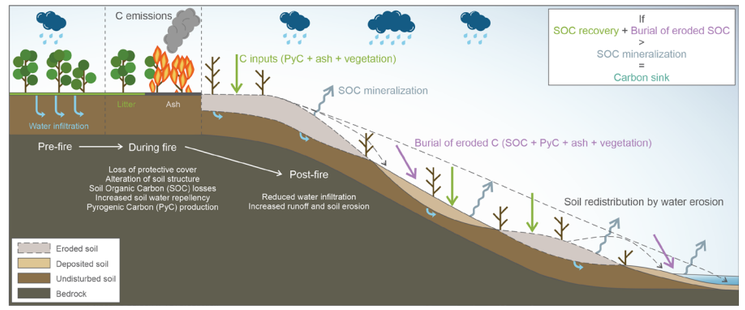


Figure 1. Representation of fire-induced changes in the soil that lead to enhanced erosion and interacting processes in the post-fire soil erosion response that determine its potential to act as a C sink. Note that these processes occur at different times and scales.



GT 12 - 330 - O

POST-WILDFIRE CHANGES IN SOIL CHEMISTRY AND WATER REPELLENCY IN THE EUROPEAN ALPS: A MID-TERM CASE STUDY

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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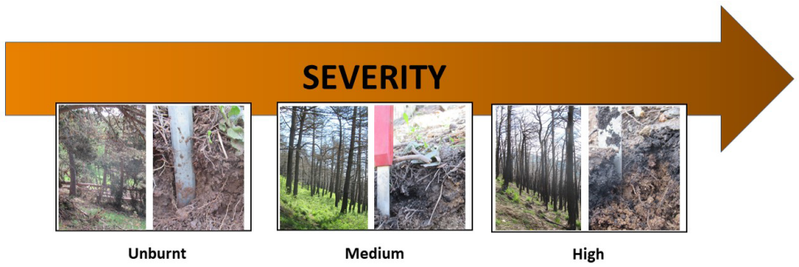
Wildfires are natural disturbances that occur worldwide, shaping ecosystem structure and composition, and impact the topsoil with long-lasting effects on the biogeochemical cycling of many elements. Water repellency (WR) is one of the main soil properties to be altered by fires and, in concomitance with the loss of canopy and litter cover, it can trigger severe surface runoff and erosion. The European Alps are being increasingly affected by extreme fire events due to land abandonment and climate change, and the steep slopes of this environment further exacerbate its fragility, but understanding of post-fire ecosystem functioning in these environments is poor.

We sampled fire-affected forest topsoils (0-2 cm and 2-5 cm) of the European Alps to assess the recovery of soil physico-chemical properties in the mid-term, 3 years after fire occurrence. We selected an area that was homogeneous in terms of lithology and vegetation type (Pinus sylvestris L., Scots pine), where the only variation factor was the degree of severity of the disturbance.

After 3 years, shrubs recolonization was spread but bare soil was still exposed in most of the burnt sites. The burnt sites were characterized by the presence of a 0-2 cm dark-colored pyrogenic horizon, which had significantly higher pH and a greater content of pyrogenic carbon respect to unburnt sites. There were no significant differences in terms of moisture, C/N ratio, available phosphorus, and organic carbon content in the 0-2 cm layers according to severity. The 2-5 cm layers of the burnt sites, instead, had significantly lower organic carbon and nitrogen contents, lower moisture, higher pH values, and a higher content of fine silt and clay than the unburnt sites, likely due to the heat-induced destruction of sand-sized aggregates.

Water repellency as estimated in the field did not agree with contact angle measurements performed in the laboratory, likely because of differences in sample moisture (field moist vs. dry soil). Both measures revealed that WR had a patchy distribution and was higher in uppermost horizons. Strongly water repellent topsoils (contact angle>110°) were common in low severity sites that had abundant organic carbon contents, high C/N values, intermediate contents of pyrogenic carbon and dominance of exposed bare soil.

These findings reveal that a period of 3 years is not sufficient to observe a full recovery of soil properties in fire-affected forests of the European Alps, where the re-colonization of Scots pine is slow, and mostly proceeds close to the fire perimeter margins or in proximity of the surviving seed-trees.



Site and topsoil features according to fire severity degree.

GT 12 - 414 - O

CHEMICAL SOIL PROPERTIES AND PEDOGENETIC INDICES AS KEY FACTORS TO IDENTIFY SOIL DISCONTINUITIES ACTING AS POTENTIAL FAILURE SURFACES OF SHALLOW LANDSLIDES IN A PILOT CATCHMENT OF THE CALABRIA REGION (SOUTHERN ITALY).

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES

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Shallow landslides are known to be natural processes actively modifying landscapes. The shallow landslides are a major denudation process in mountainous and hilly areas that have a wide impact on the natural environment, infrastructure, and human life. Soil cover properties can influence the development and extent of shallow landslides, since pedogenetic processes can form discontinuities acting as potential failure surfaces within the soil profile. In the framework of the project SOIL SHADES – SOIL features and pedogenic processes as predisposing factors of SHAllow landsliDES, funded by Next Generation EU, National Recovery and Resilience Plan (PNRR) of Italy, Research Projects of Significant National Interest (PRIN), an integrated multi-scale and multi-analytical approach has been carried out in a pilot catchment (Turbolo Stream) of the Calabria region (southern Italy). Six soil profiles were analysed across the whole basin, in the detachment crowns of the main identified landslides. The selected soils were formed from lithologically different parent materials: metamorphic rocks, clay deposits, sand deposits, sand and conglomerates. Very different were revealed the soil properties throughout the Turbolo basin: strongly acid, loam and sandy loam the soils over the metamorphic rocks of the forestry environment, strongly alkaline and silty clay loam the soils over the clay deposits, while the soils over the sand and conglomerates showed a wider range of variability, from strongly acid to moderately alkaline reaction and sandy loam to sandy clay loam texture. Selectively extracted (ammonium-oxalate-o and sodium-dithionite-citrate-bicarbonate-d) and total content (t) of Fe and Al were used to calculate pedogenetic (including Feo/Fed, Fed/Fet, Fet-Fed) and andic (% Alo + 0.5 Feo) indices. Higher Feo/Fed ratios (2.38-3.88), associated with the lowest Fed/Fet ratios (0.005-0.008), were generally found for the soils developed from sand and conglomerate deposits, suggesting a low crystallinity degree of the Fe-forms and a low degree of weathering for the Fe-containing primary silicates vs. the crystalline mineral forms. Evidence of the clay illuviation process was found in all the soils over the sand deposits, where the argic horizons represent a pedogenic discontinuity starting or just below the topsoil or at a variable depth between 50 and 140 cm. On the contrary, the soils developed from the clay deposits showed a lower Feo/Fed ratio (2.12-2.19) until 110 cm and a sharp increase until 4.46, while slightly higher Fed/Fet ratio (0.013-0.016) compared with the soils over the sand, reflecting a higher degree of weathering. In one of the soils developed from the metamorphic rocks, vitric properties (0.4-0.8 % of Alo + 0.5 Feo and more than 35% of phosphate retention) have been identified. Worthy of note, both the soils developed from the metamorphic rocks showed the highest Fed/Fet ratios (0.018-0.023).



GT 12 - 430 - O

ARE SOIL FEATURES AND PEDOGENIC PROCESSES PREDISPOSING FACTORS OF SHALLOW LANDSLIDES? SOME RESULTS FROM THE ONGOING PROJECT SOIL SHADES

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Although a wide scientific literature investigated the effects of weathering processes and other factors on the triggering of landslides, the role of pedogenesis and soil features on shallow landslides has been poorly explored so far and the soil has often been considered as a unique homogeneous body. Several studies neglect the intrinsic lateral and vertical spatial variability of soils, related to changes in soil properties in respect of the parent materials, driven by soil-formation processes. This may lead to a differential behavior of geomechanical properties through the soil profile according to its differentiation into pedogenic horizons, possibly controlling the location of the failure surface(s). The ongoing project “SOIL SHADES – SOIL features and pedogenic processes as predisposing factors of SHAllow landsliDES”, funded by Next Generation EU, National Recovery and Resilience Plan (PNRR) of Italy, M4.C2.1.1., National Research Programme (PNR)–Research Projects of Significant National Interest (PRIN), aims at exploring this issue. We selected a pilot catchment (Turbolo Stream) in Calabria (southern Italy), which can be considered as representative of other drainage basins in other Mediterranean and mid-latitude regions because of its geo-environmental features. Therein we applied an integrated multidisciplinary, multi-analytical, and multiscale approach including geological, geomorphological, pedological, geotechnical, and geophysical investigations. After implementing an inventory of mass movements based on field surveys and aerial photo interpretation, we selected six reference soil profiles for detailed study. They were mostly located along the main scarp of some shallow landslides and represent different soil types, developed on different lithologies and landforms. Electromagnetic induction (EMI) and electrical resistivity tomography (ERT) surveys at some sites enabled us to map the soil spatial variability across the landslide area, showing a good consistency between the depth of the landslide scarp, of the soil profile, and of the potential failure surface. The soil profiles were described in the field and each horizon sampled for physico-chemical and geotechnical analyses, coupled with micromorphological observations of thin sections. Major data showed clear changes of pedological and geotechnical properties with soil depth in the different pedogenic horizons (especially the deepest), although they showed different patterns in each soil profile, thus supporting a prominent role of pedogenesis on the modification of the original properties of the parent materials. Such changes can be potential predisposing factors of shallow landslides, controlling the depth of the failure surface(s). However, the different soil types showed varying geomechanical properties related to different pedogenic features and indicated a complexity of mutual interactions between parent rocks, soil-formation processes and geomorphic dynamics.

GT 12 - 631 - O

SOIL RESPONSE TO MICROPLASTICS FOLLOWING WILDFIRE: INSIGHT FROM A SOIL COLUMN EXPERIMENT

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Microplastic (MPs, 1 µm–5 mm) pollution is increasingly recognized as a major environmental issue, especially in terrestrial ecosystems, with soil acting as the largest global reservoir. In forest environments, MPs are dispersed by wind far from their original sources and deposited in soil, where they can accumulate and affect its properties and functions. However, their dynamics in forest soils are still poorly understood, particularly in fire-prone areas like the Mediterranean. Wildfires may significantly affect MPs, altering their physical and chemical characteristics, and, ultimately, their interactions within the soil matrix. Studying MPs in soils is further complicated by the presence of pyrogenic organic matter produced by wildfires, which hinders the isolation and accurate characterization of MPs.

This study aimed to investigate the effects of MPs on forest soils of a Mediterranean area, both before and after being affected by fire. The MPs selected — high density polyethylene (HDPE), polypropylene (PP) and polystyrene (PS) — represent some of the most common polymers found in forest soils and differed in size and shape. Undisturbed soil columns were sampled from the coastal Campomarino forest (Molise region, Southern Italy) using 13 cm wide and 20 cm long cores, yielding 15 cm intact soil profiles. MPs were added at a rate of 0.15% to the upper 2 cm of the soil. To simulate wildfire combustion, some of these MP-added layers were burned in a muffle. In total, 20 columns were prepared: 6 with HDPE <106 µm, 6 with PS (106–500 µm), and 6 with fibrous PP (0.5–1 mm long, 1 mm wide), each with 3 replicates of burnt and unburnt MPs. Two columns were used as controls without MPs. Simulated wet–dry cycles mimicked 25 years of rainfall, equivalent to the average fire recurrence in Mediterranean forests.

Results showed more pronounced vertical migration for smaller MPs (HDPE, PS), especially in burnt treatments, despite the difficulties associated with their extraction. No changes in texture were detected, although slight porosity variations were noted. Burnt MPs increased soil pH, cation exchange capacity, and water-holding capacity, particularly in their fibrous form. Regardless of fire, saturated hydraulic conductivity decreased with PP fibers, while HDPE and PS led to increases. These findings suggest that fire plays a key role in modifying both the behavior and impact of MPs in forest soils, amplifying the environmental damage associated with vertical dispersion. Moreover, this research highlights the need to develop new extraction methods for such altered MPs.

ACKNOWLEDGEMENTS

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GT 12 - 10 - F + P

THE FLOODING IN EIGHT (8) VILLAGES UNDER KWAITA BLOCK KWALI AREA COUNCIL OF THE FEDERAL CAPITAL TERRITORY ABUJA.

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 08. SOIL-PLANT-WATER INTERACTIONS

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This flood affected about 10,000 hectares of Farmland and more than 500 farmers were involved. Besides quite a large number of crops like Maize, Rice, Cassava, Plantains, Yams, Banana, Soya beans , Cowpeas , Vegetables and other crops were destroyed. The dates of the rain fall was noted as 23rd and 24th August 2018. While there was farm visits to the affected sites on 25th -24th August, 2018. Pictures were taken to support findings. Meanwhile, to enable the Project determine the extent and impact of the damage this flood disaster wrecked on the affected communities the following field staffs swift into action by carrying out proper inventory and on the spot assessment:1)Village Extension Agent Mr Rabiu Mohammed (2) Block Extension Supervisor Mr Michael Adedotun Oke (3) Zonal Extension Officer Mr Katuka Dauda. It was generally observed that, the rain pour down heavily and persistently for more than 12 hours which in turn adversely affected the livelihood of the community and the farmers in the following villages mention below in Kwaita Block 1.Kwaita 2.Pukafa 3.Eke 4.Tekpose 5.Gadabiu 6.Ashara 7.Fugbe and 8.Wako. In- view of the above reasons highlighted the farmers needs urgent assistance of the Honourable Minister FCT, Agricultural And Rural Development Secretariat as well as the FCT Agricultural Development projects to provide succour and timely intervention to this farmers in this farming communities to ameliorate their suffering and pains that have be inflicted on them by this flood menace and the paper suggest ways in which to prevent the occurrence of flood in the Federal Capital Territory in Abuja Nigeria.

Keywords: Flood, Kwali, farmers, Kwaita Block, Federal Capital Territory

GT 12 - 9 - P

THE RECENT FLOOD THAT OCCURRED IN MAIDUGURI, NIGERIA

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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In terms of the economic problems they are facing, which have resulted in the degree of community displacement in Maiduguri, the effects and government's individual attempts to salvage the economy's devastation and the national level flood hazards against the citizens of Maiduguri have become a life setback. It is impossible to overstate the harm being done to people's lives, businesses, schools, farming activities, as well as the deaths of people at the hands of the national phenomena that led to the dam's reopening and the loss of many lives as a result of the development.

Concern for the dam for human use is also evident in the dam's poor management, and the budgeted funds were not used appropriately, which may have contributed to the unfortunate events that befell the Maiduguri people, for whom this was a bad time to live.

While the opportunities for detailed reporting, the flooding, are provided by the many Nigerian media outlets, etc. Vanguard and Daily Trust newspaper. We analyst the repository in order to have a thorough report, and coming to the conclusion that the dam's reopening, causes the flooding and the subsequent development that followed the downpour of rain had consequences. We also looked at the various effective, donations and the amount that was supported, the impact made by individuals and cooperative organizations.

The inhabitants of Maiduguri are experiencing great hardships due to insecurity and poverty, through the flood. Our recommendation is to try and finish the dam. The majority of the donated funds should also be used wisely and quickly, and more importantly, they should be used to develop Maiduguri's economy overall and spend the funds sensibly to ensure that the general money is distributed equally.

KEYWORDS

Dam, Maiduguri, human, flood, inhabitants, experiencing

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GT 12 - 97 - P

RECOVERY OF SOIL PROPERTIES INFLUENCED BY TREE SPECIES AFTER FOREST FIRE DISTURBANCE

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The intensity of fires is predicted to increase due to climate change and the associated increasingly frequent droughts. However, especially in the temperate climate zone, there is still a lack of study on forest ecosystem recovery in sites following fire. The aim of this study was to assess the regeneration of soil properties after a forest fire, including the stock and properties of soil organic matter, under the influence of various tree species: Scots pine (Pinus sylvestris L.), silver birch (Betula pendula Roth), and black alder (Alnus glutinosa (L.) Gaertn.). The research plots were established on sandy soils (Podzols and Arenosols) in pure 30-year-old stands of the studied tree species, at a post-fire site in southern Poland. Control plots were also established in stands at sites where no fire had occurred. In each study plot, samples were taken from the organic and mineral soil horizons. Tree foliage samples were also collected to determine the nutrient supply of the trees. The basic soil properties (texture, pH, bulk density), the contents of organic carbon (C) and macroelements, the biomass of the soil microorganisms, the content of labile fractions of C and nitrogen (N) extractable in cold and hot water, and the particulate organic matter were determined in the soil samples. It was found that, approximately 30 years after the fire, the soils had similar organic C stocks compared to undisturbed soils at control sites, but differed in the stocks of the labile C and N fractions. The post-fire soils were characterized by a less stable C pool due to a higher stock of particulate organic matter compared to the soils from the control sites. However, the N pool was more stable in the post-fire soils than in the control sites due to the lower share of the most labile N fractions in the total N content. The tree species differently affected the post-fire soils. The soils under pine were characterized by the least stable soil organic matter, which may have affected the intensification of the podzolization process under stands of this tree species. Birch stimulated the development of a large microbial biomass. The soils under black alder were characterized by the highest acidity and the lowest phosphorus (P) content. The C:N:P stoichiometry ratios in the soils and tree foliage indicated that the factor limiting the growth and development of alder stands in the post-fire area was P, and, in the case of pine and birch, N. The results of the study indicate that the tree species used for the reforestation of post-fire sites are of key importance in the properties and regeneration of the ecological functions of the soils. However, black alder, introduced to post-fire sites in the form of pure stands as a phytomeliorative species to increase the soil organic matter and N pool, has limited use.

GT 12 - 146 - P

MITIGATING SOIL EROSION AFTER FIREBREAK CONSTRUCTION: THE ROLE OF WOODCHIP MULCHING IN MEDITERRANEAN FORESTS

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 05. SOIL HYDROLOGY & EROSION

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Wildfires are a major disturbance in Mediterranean ecosystems. In Castilla-La Mancha (Spain) fire suppression efforts often involve heavy machinery to construct firebreaks. However, this practice compacts the soil, remove vegetation, and increase erosion risk. This study evaluates the effectiveness of immediate post-fire woodchip mulching (M) —applied both to burned areas (B) and unburned (UB) machinery tracks—in reducing erosion and restoring soil hydrological function in a pine forest in the Sierra del Monje, after a high-severity wildfire in 08/2024.

Four treatments were evaluated in 28 plots (1m2): (1) UB soil disturbed by machinery without M, (2) UB disturbed soil with M, (3) B soil without M, and (4) B soil with M. Burned pine woodchips (3 cm thick) were applied to cover 85% of the soil surface. Rainfall simulations mimicking intense Mediterranean storms (432 mm/h for 5') were used to assess runoff, infiltration, and soil loss, along with several soil physicochemical chemical properties.

Firebreak construction significantly increased soil erosion. The highest soil loss (1.14 t/ha) occurred in UB machinery-disturbed plots without M, exceeding even B untreated areas (0.64 t/ha). M reduced erosion by over 80% in disturbed UB areas and by about 70% in B plots, though it had limited impact on infiltration or runoff. These findings suggest the mulch's primary benefit is physical surface protection (reducing rainsplash), rather than short-term hydrological or biochemical improvement. M significantly improved ground cover but did not affect soil bulk density, pH, conductivity, or organic matter in the short term. Machinery tracks had high bare soil cover and compaction, while B areas exhibited ash cover and water repellency. Strong links between erosion and surface cover were found but not between runoff and soil loss. Despite limitations (e.g., use of simulated rain), erosion rates remained below critical thresholds (<10 t/ha/year).

The study concludes that mechanized firebreak construction exacerbates soil degradation beyond fire effects alone. Woodchip mulching, using locally available post-fire residues, offers a cost-effective, sustainable tool to mitigate erosion and could be integrated into post-fire land management. However, long-term monitoring is needed to assess its impact on infiltration, soil recovery, and ecosystem resilience.

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GT 12 - 273 - P

WHAT DO WE KNOW ABOUT POST-FIRE SOIL EROSION MITIGATION?

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 05. SOIL HYDROLOGY & EROSION

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Wildfires are considered to be one of the main causes of soil erosion and land degradation processes in fire-prone areas, which are expected to increase in the future because of intensifying fire regimes across the world as a consequence of changes in climate and land use. To guarantee the sustainability of fire-prone ecosystems and protect the values at risk downstream from the fire-affected areas, it is vital to mitigate fire-enhanced hydrological and erosive response.

In this presentation, we will go through some of the main research questions on post-fire soil erosion mitigation, showing the state-of-the-art and findings from recent global analyses [1, 2]:

- Which are the most effective treatments and at which application rates?
- How do key-variables in post-fire soil erosion determine the effectiveness of the treatments?
- How much does it cost to apply these treatments?
- How much does it cost to reduce post-fire erosion to tolerable rates?
- Where and when are post-fire erosion mitigation treatments justified?

The outcomes of this research have important implications for informing post-fire emergency stabilization decision-making, and show the research gaps to be addressed in future research

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GT 12 - 565 - P

AI4FIRES: USING ARTIFICIAL INTELLIGENCE AND GEOSPATIAL DATA FOR POST-FIRE MONITORING AND FOREST MANAGEMENT

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 16. CONNECTING PEOPLE AND SOILS

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Fire is a natural component of many ecosystems. However, in recent decades, wildfires have increased in extent and intensity, causing widespread socio-economic and environmental damage. In the Mediterranean region of Europe, particularly in Spain, the combination of rural abandonment, the expansion of poorly managed forested areas, and rising temperatures and droughts linked to climate change has led to larger wildfires in recent years. These wildfires cause severe damage to the biodiversity and ecosystem functioning, while also severely impacting the economy, health, and well-being of many surrounding communities.

The worsening conditions have highlighted major gaps in scientific knowledge and the urgent need to develop advanced tools and technologies to support decision-making through holistic approaches capable of addressing both current and future challenges. Effective management must integrate both prevention and post-fire recovery, incorporating ecological and socioeconomic factors. In this context, soil emerges as a relevant component to consider given its role in maintaining ecosystem stability and functionality. Fire history, fire severity, and post-fire management trigger complex responses in soil dynamics that directly affect landscape evolution over the medium and long term. Understanding how these variables interact is essential to anticipating risks, designing adaptive management strategies, and moving toward more resilient land-use planning.

Integrating remote sensing data with advanced analytical techniques, such as machine learning algorithms, enhances our ability to model and predict ecological trajectories following fire disturbances. Designing future forest management strategies that foster more sustainable post-fire regeneration requires up-to-date and accessible information for public administrations. The IA4FIRES project therefore aims to develop a post-fire monitoring system applying artificial intelligence techniques for processing geospatial data. The project operates at the municipal scale of Alicante, Spain, as local administrations hold various responsibilities related to land-use planning but often lack, especially in smaller municipalities, the technical resources needed to perform these tasks using ideal information sources. We are focused on a group of municipalities in the Vall d´Ebo (Ebo’s Valley) that have been severely affected by large wildfires in recent decades (in 2000, 2009, 2015, and 2022). The project will create a public-facing analysis and a visualization platform to track post-fire regeneration in small municipalities heavily impacted by wildfires. This platform will include both historical land cover change maps to understand baseline conditions and the automated calculation of post-fire regeneration parameters using the most up-to-date satellite imagery available.



GT 12 - 859 - P

EFFECTS OF FOREST FIRE ON SOIL PROPERTIES DEPENDING ON ENVIRONMENT AND SOIL FACTORS

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Forest fires cause significant changes in soil properties. Detection of these changes directs afforestation and reclamation works to be carried out after the fire. The severity of the change in soil properties naturally depends on the severity of the fire, its duration, soil type, soil moisture, pre- and post-fire vegetal biomass, climatic conditions, topography and many other factors. However, re-investigating all soil properties after a fire can cause both financial and time loss. Predicting the physical, chemical and biological changes in soil after fires can prevent these losses. In this context, it is important to characterize the common changes that occur in soils after forest fires. In this review, the common changes in soil properties as a result of the researches carried out after forest fires were determined and it was aimed to contribute to reclamation works.

KEYWORDS

Fire, change in soil properties, forest fire, cover fire, plant nutrients.

GT 12 - 960 - P

BIOCHEMICAL ANALYSIS OF FIRE-AFFECTED ANDOSOLS IN TENERIFE (CANARY ISLANDS) – EFFECT OF FIRE SEVERITY AND RELATED SOIL CHEMICAL PROPERTIES

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Between August and October 2023, a huge wildfire affected ca. 14000 ha of forest areas in Tenerife (Canary Islands). Andosols were highly damaged by smouldering fires that exhausted humus-rich A horizons locally, exposing the underlying layers. We analysed 14 soil samples gathered in April 2025 in an area under potential vegetation of evergreen, laurel forest, afforested with exotic pine trees (Pinus halepensis) when the fire swept across it. Sampling considered three burn severity levels: (i) Unaffected areas; (ii) Areas with charred soil A horizon and (iii) Areas lacking A horizon due to slow consumption (zero, moderate and high severity, respectively). Soil properties included: pH (1:5 in H2O), oxidizable C, water-extractable NO3-, as well as acid phosphatase, b-glucosidase, urease and dehydrogenase activities. A clear relationship between fire severity and enzymatic activities (especially for phosphatase and dehydrogenase) was observed. Fair regressions were obtained for the oxidizable C content and some enzyme activities. No clear relationship was observed between soil pH and any enzymatic activity. Soil nitrate contents were highly variable, and were related to most soil properties studied. The burned area is far from being recovered of fire effects in terms of biochemical activity. Given the massive losses of surface soil horizons in the area and the dependence of soil biochemical activity on organic C content, a long time is expectable before soil microbiota and the entire ecosystem reach a pre-fire state.

ACKNOWLEDGEMENTS

The Canarian General Foundation of the ULL has received a 314.202,35 € budget from the Area of Environment, Sustainability, Security and Emergences of the Tenerife Island Council to study eroded soils affected by the 2023 wildfire.

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Pearson's Correlations

		Phosphatase	βGlucosidase	Urease	Dehydrogenase	pH	Oxidizable C	Nitrate
Phosphatase	Pearson's Correlation	1						
	Sig. (bilateral)							
	N	14						
βGlucosidase	Pearson's Correlation	0,777**	1					
	Sig. (bilateral)	0,001						
	N	14	14					
Urease	Pearson's Correlation	0,683**	0,556*	1				
	Sig. (bilateral)	0,007	0,039					
	N	14	14	14				
Dehydrogenase	Pearson's Correlation	0,821**	0,821**	0,644*	1			
	Sig. (bilateral)	0,000	0,000	0,013				
	N	14	14	14	14			
pH	Pearson's Correlation	-0,531	-0,318	-0,348	-0,494	1		
	Sig. (bilateral)	0,051	0,268	0,223	0,073			
	N	14	14	14	14	14		
Oxidizable C	Pearson's Correlation	0,923**	0,679**	0,672**	0,822**	-0,639*	1	
	Sig. (bilateral)	0,000	0,008	0,008	0,000	0,014		
	N	14	14	14	14	14	14	
Nitrate	Pearson's Correlation	0,721**	0,767**	0,647*	0,662**	0,452	0,685**	1
	Sig. (bilateral)	0,004	0,001	0,012	0,010	0,105	0,007	
	N	14	14	14	14	14	14	14

**. Significant at α = 0,01 (bilateral).
*. Significant at α = 0,05 (bilateral).

Correlation Analysis



GT 12 - 972 - P

ASSESSING WILDFIRE EFFECTS ON CHEMICAL PROPERTIES, ENZYMATIC ACTIVITY, AND FUNGAL COMMUNITY COMPOSITION IN A MEDITERRANEAN FOREST SOIL

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 04. SOIL BIOLOGY

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This study investigates the impact of wildfire on the chemical composition, extracellular enzyme activities, and fungal community composition of a Pinus pinaster forest soil in Monte Pisano, Pisa, Italy. In September 2023, approximately 6 hectares of forest were affected by a high-severity, high-intensity wildfire. Six months post-fire, soil samples were collected from three representative burned plots at a 10 cm depth and analyzed for carbon (C), nitrogen (N), δ^13^C isotopic ratios, metal content, and pH. Additionally, five soil cores were collected from each plot using a sterilized soil corer and stored at 4 °C for subsequent metabarcoding analysis. For comparison, corresponding soil samples for chemical and metabarcoding analyses were collected from three plots unaffected by the 2023 wildfire where the last recorded fire was in 1998. The study focused on the activity of key enzymes involved in nutrient cycling, including β-1,4-glucosidase (BG), β-N-acetyl-glucosaminidase (NAG), acid phosphatase (AP) and arylsulphatase (AR). Fungal community composition was assessed through DNA extracted from soil and subjected to metagenomic analysis. The findings revealed no statistically significant differences in total C, N content, and δ13C values between 2023 and 1998 burned sites. However, P and S concentrations were notably higher in the 1998 burned site (P: 196 mg/kg, S: 297 mg/kg) compared to the 2023 burned site (P: 79 mg/kg, S: 190 mg/kg). In contrast, the 2023 burned site exhibited elevated concentrations of zinc (Zn: 107 mg/kg), lead (Pb: 113 mg/kg), and arsenic (As: 26 mg/kg) relative to the 1998 burned site (Zn: 39 mg/kg; Pb: 55 mg/kg; As: 6.5 mg/kg). Moreover, the enzyme activities were significantly reduced in the 2023 burned site. Metabarcoding analysis of the fungal communities revealed a significant shift in community composition between the sites burned in 2023 and 1998. At the phylum level, the 2023 burned site showed an increased relative abundance of Ascomycota (53.18%) and Mucoromycota, along with a marked decrease in Basidiomycota (26.24%), compared to the 1998 burned site where Basidiomycota were more prevalent (59.10%), particularly ectomycorrhizal taxa associated with plant roots. In contrast, the 2023 burned site exhibited a higher presence of saprotrophic fungi. Notably, pyrophilous fungal genera such as Morchella spp., which were absent in the 1998 burned site, were detected in the 2023 burned site. These findings underscore the importance of studying different fire regimes to understand temporal changes in soil chemical, biological, and microbiota responses to evolving environmental conditions.

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GT 12 - 975 - P

SCORCHED SOILS: SEVERITYDRIVEN EDAPHIC RESPONSES TO THE 2023 TENERIFE (SPAIN) WILDFIRE

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 09. SOIL HEALTH

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The increasing occurrence of highseverity wildfires in island regions such as the Canary Islands (Spain) poses urgent challenges for ecosystem conservation and postfire management. In this context, the present study focuses on how different severities of the large wildfire that burned over 12,000 ha in Tenerife in August 2023 affected key soil’s physicochemical properties, treating severity as a driver to understand the magnitude and extent of soil alterations after the fire. Using a temporal design with two sampling campaigns, one just after the fire and the other one year later, multiple soil parameters were examined in unburned soils (control) and in areas affected by moderate and high severity. The results obtained show that severity strongly influences soil alteration, impacting key indicators such as pH, electrical conductivity, available nutrient concentrations, cationexchange capacity, and micronutrient content. The most notable effects were observed in areas of high severity, with significant differences in most of the chemical parameters analysed, mainly due to the combustion of organic matter and the accumulation of ash, which significantly altered the equilibrium of the surface soil. Moderate severity areas behaved as an intermediate step between control and high severity ones. Similar trends were observed, with significant increases in parameters such as electrical conductivity, available phosphorus and some nutrients, although these increases were less important than in high severity areas. Most parameters returned pre-fire values after one year, which could be interpreted as a sign of soil recovery. However, this does not necessarily indicate full functional restoration of the soil, as specific properties were assessed in this study and a complete recovery of its ecological functions cannot be assumed. Moreover, for some parameters such as phosphorus, values even dropped below control values after one year, which could compromise the fertility and regeneration of the ecosystem in the mid-long-terms. These findings underscore the importance of taking into account fire severity when planning post-fire monitoring and restoration actions. Rather than applying uniform measures, it is necessary to adapt interventions according to the level of soil impact, as the soil responds differently depending on the severity of the fire.

ACKNOWLEDGEMENTS

The Canarian General Foundation of the ULL has received a 314.202,35 € budget from the Area of Environment, Sustainability, Security and Emergences of the Tenerife Island Council to study eroded soils affected by the 2023 wildfire.



GT 12 - 976 - P

SOIL IN FLAMES: COMPARATIVE IMPACTS ACROSS AFFECTED VEGETATION TYPES IN THE 2023 TENERIFE (SPAIN) WILDFIRE

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 09. SOIL HEALTH

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Wildfires represent one of the main threats to soil stability in island ecosystems. The ecological complexity and heterogeneity of vegetation cover in territories such as Tenerife (Spain) significantly influence how fire spreads and alters edaphic properties. This study analyzes the impact of the large wildfire that occurred in August 2023 on key soil properties, focusing primarily on the differences between vegetation types affected by high-severity fires. Based on a sampling strategy in four vegetation formations: Monteverde, Canarian pine forest, radiata pine forest, and reforested areas, multiple physical-chemical soil variables were evaluated at two key time points: immediately after the fire and one year later. The results reveal that the intensity and persistence of the impacts depend not only on the vegetation type, but also on the mode of fire propagation. Monteverde, characterized by deep soils with high organic matter content, was the most affected formation after the fire. This greater alteration is associated with the development of ground fires, whose prolonged exposure to high temperatures caused severe degradation of the soil profile. A high loss of organic matter was observed, along with ash formation, which had relevant effects on most of the properties analysed, such as pH, electrical conductivity, nutrient availability, water retention capacity, and aggregate stability. In contrast, soil properties at the Canarian pine forests showed moderate impacts, likely due to the type of fire that predominated, mainly crown fires, in which the temperatures reached in the soil profile were lower and less persistent. The radiata pine forest, which experienced ground fire in some areas, showed an intermediate response, with significant alterations in key parameters. Reforested areas displayed a more heterogeneous response, influenced by the compositional diversity of these forest stands. After one year, however, the analyzed parameters returned to values close to those of unburned areas across all vegetation types. This study highlights that the interaction between vegetation type and fire type is crucial to understanding soil responses after a wildfire. Therefore, it is recommended to incorporate this factor when planning post-fire restoration strategies, and to adapt actions to the characteristics of each ecosystem, avoiding generic treatments in ecologically diverse scenarios.

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The Canarian General Foundation of the ULL has received a 314.202,35 € budget from the Area of Environment, Sustainability, Security and Emergences of the Tenerife Island Council to study eroded soils affected by the 2023 wildfire.

GT 12 - 1016 - P

INFLUENCE OF FIRE ON SOIL ORGANIC MATTER AND ITS FRACTIONS IN FOREST ECOSYSTEMS

GT 12. SOIL NATURAL HAZARDS: FIRES, FLOODINGS, LANSLIDES / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Fire effects on soil properties can be varied and very complex, inducing temporary changes or substantial and permanent ones [1] The most common direct fire effects on soil include changes to organic matter content and quality, alteration of the microbial community, changes in the degree of reaction and physical properties including water repellency and aggregate stability [2].

The BIOSFER3A project, financed by the National Biodiversity Future Center – NBFC (SPOKE4), aims at exploring the relationship between biodiversity and functionality in natural ecosystems, with a particular focus on the role of forest ecosystems in the carbon and nitrogen cycles and greenhouse gas balance in the atmosphere. The project also explores the role of climate change and fire in shaping the response of forest C and N cycles to fire disturbance. Here we present the results of soil organic carbon distribution in the topsoils (0-20 cm) sampled in November 2024 from the BIOSFER3A study sites, coniferous and broadleaved forest stands that have undergone strong wildfire in 2023 and in coniferous stands also in 2017, in Morrone mountain (Abruzzo), part of the 12 NBCF SAV sites of Spoke 4. In addition, we evaluated the effect of wildfire on the distribution of particulate (POM) and mineral associated organic matter (MAOM), taking into account that these two components of soil organic matter differently affect its long-term stabilization.

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GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS-POSTER-MARK

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 13 - 196 - O

THE RISK FOR HUMAN HEALTH FROM THE SOILS OF URBAN GARDENS ESTABLISHED IN RECLAIMED CLAY PITS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The large popularity of urban gardens as the sites for family recreation and small-scale horticulture (vegetable, fruit, flowers) in Central Europe since the 1920s forced establishing the gardens on the reclaimed post-mining sites as the only available terrains in the rapidly growing cities. The topsoil layers of the reclaimed sites were constructed from humus-rich soil, transported from the other mining and construction sites, and considered free of contaminants. However, the open casts of the former clay and sand pits were first filled with ash and slag from coal burning and construction rubble, often containing an admixture of household or industrial wastes. This infilling, starting at 30-60 cm from the soil surface, is often characterised by unfavourable physicochemical properties (including very coarse, very fine texture, cementation, very high or very low pH) and may contain variable xenobiotics, in particular heavy metals, released in course of weathering (decomposition) of technogenic materials. The study carried out in one of the urban garden complexes in Wroclaw (SW Poland) showed a clear relation of spatial soil contamination with the history of the site. The concentrations of Hg, Cd, Pb, Cu and Zn in the humus horizons reached 1, 2, 110, 60, and 370 mg/kg, respectively, in non-reclaimed (natural) soils. However, the content of Hg, Cd, Pb, Cu, and Zn was up to 5, 6, 740, 920 and 2340 mg/kg, respectively, in the topsoil layers of the reclaimed part of the gardens. The latter concentrations were obviously affected by technogenic subsoil materials containing up to 5, 8, 1520, 690, and 3600 mg/kg of Hg, Cd, Pb, Cu and Zn, respectively. At such a high health risk to gardeners, contaminated parts of gardens should be excluded from food production and converted to parks, as their remediation seems ineffective technically and economically.

GT 13 - 318 - O

DE-SEALING OF URBAN SOIL AND CONTAMINATION RISK: A CASE STUDY FROM THE REUSES PROJECT

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 09. SOIL HEALTH

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Soil sealing compromises the ecosystem services provided by soil. In addition to the loss of food production, soil sealing disrupts exchanges with the atmosphere and the surrounding environment, negatively affecting water infiltration, purification capacity, and carbon sequestration. As reported by the European Environment Agency, more than 1.1 million hectares of land were sealed across the EU between 2000 and 2018. In response, strategies such as de-sealing techniques have been proposed to counteract this growing issue. The REUSES (Restore Urban Sealed Soil for Alternative Ecosystem Services) project operates within this context, aiming to rehabilitate abandoned sealed urban soils by converting them into community gardens. To ensure safe food production and public health, it is essential to monitor soil properties, particularly the presence of contaminants such as hycarbons. Hydrocarbons, mainly BTEX and polycyclic aromatic hydrocarbons (PAHs), may have different origins, although they are primarily generated by anthropogenic activities. In urban areas, these compounds have gained increasing attention due to their carcinogenic and mutagenic properties, with a focus on the potential sources of pollution. Among these, diagnostic ratios are widely used to determine the potential source by comparing the relative levels of individual PAHs. Therefore, this study aimed to monitor de-sealed soil properties of two REUSES project sites over three time points: immediately after surface cover removal (T0), after ~2.5 months (T1), and after ~5 months (T2). The focus was on the presence and potential sources of benzene, toluene, ethylbenzene, and xylene (BTEX), as well as low and high molecular weight PAHs (LMWPAHs and HMWPAHs, respectively). Both sites were characterized by fine-texture soils (silt loam to silt clay loam), moderately to strongly alkaline pH, and low total organic carbon and total nitrogen (<1.5% and <0.20%, respectively). BTEX compounds were below detection limits at all time points, likely due to their high volatility and solubility. Conversely, PAHs tended to accumulate over time, reaching concentrations for some compounds that exceeded Italian regulatory thresholds for industrial soils, although not statistically significant. Among these, HMWPAHs, such as benzo[a]pyrene (BaP) and benzo[g,h,i]perylene (BghiP), were prevalent reflecting their strong hydrophobicity and affinity for soil particles. LMWPAHs/HMWPAHs and BaP/BghiP ratios indicated a predominant pyrogenic origin, mainly due to traffic emissions. Additionally, other diagnostic ratios confirm the origin from combustion of petroleum products, such as gasoline and diesel. These findings underscore the importance of monitoring urban de-sealed soils for potential contamination. Regular assessment of soil quality is critical for guiding recovery efforts and ensuring the safe reuse of urban soils for food production and other community uses.



GT 13 - 387 - O

LITTER C:N RATIO AND SOIL WATER RETENTION DRIVE EARLY CO_2 AND N_2O EMISSIONS FROM RECYCLED LITTER ON URBAN LAWNS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Urban green spaces (UGSs) play a vital role in enhancing urban sustainability by providing ecosystem services. Lawns, which can cover up to 50–70% of UGSs worldwide, differ in their vegetation cover and generate substantial litter from a wide variety of trees, shrubs, and herbaceous plants. Much of this litter is exported, although recycling it into soil could improve soil health while reducing indirect greenhouse gas emissions associated with litter blowing, transport, and composting [1, 2]. However, litter decomposition may also lead to direct emission of nitrous oxide (N_2O)—a powerful greenhouse gas[3].

Litter biochemistry influence on N_2O fluxes during litter decomposition was studied on two lawn soils from a low- and a high-intensity management. The high-intensity management soil had higher organic C and N contents and greater water retention capacity. Five litter types with contrasted biochemistry (e.g., C:N ratios and lignin content) were selected from twenty-eight representative UGS species, which included trees, shrubs, and herbaceous plants. These litters were applied at the soil surface and incubated in the lab for 14 days (15°C, soil water content near field capacity). Carbon dioxide (CO_2) and N_2O emissions, along with mineral nitrogen dynamics, were measured throughout the incubation.

Cumulative CO_2 and N_2O emissions depend on litter C:N ratio and soil water retention capacity. Green litter with low C:N ratio (i.e., Lolium) induced higher emissions, while senescent litters with high C:N ratios (e.g., Fraxinus, Meadow grasses) induced microbial nitrogen immobilization thus limiting emissions. The high-intensity management soil showed the highest cumulative N_2O emissions across all litter types (1.5 kg N ha-1 on average) due to higher soil water retention capacity. N_2O emission factors (1.2–3.7%) exceeded the Intergovernmental Panel on Climate Change default for crop residues (0.6%). A power regression with C:N ratios from the twenty-eight collected litter types suggested average N_2O emission factors of 3.5% for green and 1.5% for senescent litters.

These findings suggest for the first time that recycling litter on an intensively managed lawn soil can result in significant N_2O emissions, due to organically rich conditions promoting notably high water retention capacity. However, litter recycling on a soil with lower water retention capacity, typically the low-intensity management soil, may represent a sustainable practice with low N_2O emission potential, while also providing substantial benefits for soil fertility, C storage, water cycling, and biodiversity.

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GT 13 - 406 - O

FROM ASH TO AGRO: ASSESSING PROPERTIES OF A THIN TECHNOSOL FOR AGRICULTURAL VIABILITY

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 02. SOIL PHYSICAL CHEMISTRY

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Reclamation of landfills often leads to the formation of Technosols—soils that differ from natural soils in composition and development. Due to their artificial origin, Technosols evolve faster and more unpredictably, showing high spatial variability that affects stability, fertility, and suitability for plant production. We assessed whether a thin (20–30 cm) soil layer, constructed on a reclaimed ash landfill in Eastern Slovenia 15–30 years ago, meets agronomic soil quality criteria. Three grassland parcels—P1 (reclaimed 2006–09), P2 (~1996), and P3 (1996–99)—used for forage production were sampled in 2024 at 0–10 cm (A) and 10–20 cm (D) layers. Measured properties included bulk density (BD), plant-available water (PAW), water-stable aggregates (WSA), texture, saturated hydraulic conductivity (Ksat), pH, organic C and N, available P and K, and PTEs (Cr, Ni, Cu, Zn, As, and Pb).

All parcels exceeded the PAW threshold, with means from 23.1 % (P3) to 26.1 % (P2) and within-parcel variability below ±5 %. WSA was consistently high, indicating stable structure despite the limited thickness and disturbances. However, localized contrasts were found, especially where poorly homogenized 'lenses' of distinct materials occurred. Sand-rich lenses exhibited higher BD, reduced WSA, and lower water content at pF 1.8, 2.5, and 4.2. Despite similar textures, Ksat varied widely, highlighting the role of structure over texture. Parcel 1 showed chemical limitations, with acidic subsoils (pH 4.53) reflecting heterogeneous fill and lack of base-rich amendments. Elevated PTE concentrations (Cr, Ni, As), were present, with the highest values in Parcel 1. Parcels P2 and P3 had neutral to mildly alkaline soils (pH 6.41–7.62), likely due to capillary rise of basic cations or bioturbation. Surface layers on P1 and P3 contained excessive plant-available P (up to 107.5 mg 100 g^{-1}), while P2 remained within optimal levels. Plant-available K was low in A layer (10.2–19 mg kg^{-1}) across all parcels, with both nutrients declining in D layer, indicating phosphorus limitation at depth. Organic matter ranged from 5.5–6 % in the A layer, decreasing to ~2.1 % in D.

After ~three decades, the Technosol quality remains uneven but generally favorable. Nevertheless, it is important to stress that, despite favorable indicators, the use of such thin soil layers over landfill substrates should not become standard practice. Older parcels—especially P2—have developed more balanced profiles with stable structure, sufficient nutrients, and fewer contamination zones, showing that even minimal reclamation can result in functional soils. Parcel 1, with a shorter maturation period and more heterogeneous fill, still contains acidic, metal-rich patches. Overall, the landfill Technosol meets many soil quality standards and supports grassland use; however, pronounced spatial heterogeneity—stemming from poor initial fill homogenization—highlights the need for targeted management of poorer areas.



GT 13 - 468 - O

USE OF WASTE MATERIALS AS FEASIBLE STRATEGY FOR URBAN DE-SEALED SOIL RECLAMATION: EVIDENCE FROM A RESTORATION CASE STUDY IN PRATO, ITALY

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 09. SOIL HEALTH

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Soil degradation is an increasingly urgent – yet often underestimated – environmental challenge. Among its various forms, soil sealing is the most severe, as it disrupts all soil-related ecosystem services. In addition to preventing further sealing and degradation, reversing soil sealing by removing unnecessary pavements in urban areas is emerging as a critical mitigation strategy. This practice helps restoring essential soil functions, while also enhancing public health and the quality of urban spaces. The desealing of underutilized surface can contribute to the long-term goal of “no net land take” by 2050. Despite its potential, urban de-sealing remains largely under-implemented. One of the main barriers is its high cost, as even the removal of a thin asphalt layer generates a substantial amount of waste, much of which ends up in landfills due to limited recycling options.

Here, we present selected findings from a one-year monitoring study conducted in a de-sealed urban area in the Municipality of Prato, Italy. The site, previously a ~170 m² parking area, was de-sealed in April 2024. The asphalt layer was removed, and urban excavated topsoil was applied over a base of existing rubble and stones. This topsoil was amended with crushed (< 2 cm) asphalt at varying rates (up to 50% w/w), along with a uniform addition of urban compost (5% w/w). All plots were sown with a standard urban grass seed mix, including species such as Lolium perenne, Festuca rubra, and Poa pratensis. We monitored vegetation growth and changes in soil physical, chemical, and biological properties to evaluate the potential of this restoration approach to enhance desealed soil health.

The results indicated that plant biomass and soil chemical properties were basically unaffected by asphalt additions, while some physical characteristics, such as bulk density and permeability, were even improved. However, biological indicators—including microarthropod diversity and enzymatic activity—declined at the highest levels of asphalt incorporation. These findings suggest that, within certain limits, the asphalt from de-sealing operations can be reused as soil components, offering both environmental and economic benefits in urban greening initiatives. The study underscores the need for further research to optimize this approach and promote the broader adoption of sustainable land restoration practices in cities.

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GT 13 - 836 - O

CHARACTERIZATION OF URBAN SOIL STRUCTURE THROUGH X-RAY MCT ANALYSIS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Characterization of urban soil structure through x-ray µct analysis

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Urban soils develop from numerous human-induced transformations, leading to highly heterogeneous soil. The understanding of urban soils is still in its infancy, particularly regarding their properties. Our research aims to study urban soil properties to improve our knowledge of these environments and their water retention, infiltration behaviour and temperature dynamics. In natural soils, the development of soil structure is dominated by biological activity. On the other hand, the dominant pedogenetic processes in urban soils are abiotic, often exhibiting various degrees of structural damage.

This research investigates the physical properties of urban soils to uncover pedogenic traits specific to urban-managed environments and their implications for soil structure. Owing to the high degree of heterogeneity, a key challenge lies in identifying, characterising, and quantifying soil aggregates. X-ray micro-computed tomography (X-ray µCT) offers high-resolution imagery capable of revealing the physical structure of soils at a micrometer scale at any point of the volume of a soil sample.

We employ this advanced technology to the urban soils of Lausanne, Switzerland. The city of Lausanne, with its diverse park areas differing in management practices and usage, provides a unique setting for this study. The city development in several phases offers a varied sample of urban soils. We collected 30 soil cores, each 10 cm deep, from ten different parks across Lausanne. Using extensive 3D imagery analysis, we identified patterns that offer new insights into urban soil structure, aggregate morphology, and surface compaction. X-ray µCT revealed detailed pore network architectures, which will serve as a foundation for urban soil structure classification. From a methdological point of view, the X-ray µCT approach allows unprecedented insights in the stucture of urban soils. Preliminary findings confirm the heterogeneity of urban soils, shaped by the presence of foreign terrric material and the intensity of management practices. Compaction greatly impact and shape poral network and therefore porosity



GT 13 - 838 - O

CONSTRUCTING TECHNOSOLS FOR URBAN GREEN SPACES: OPTIMIZING FUNCTIONALITY THROUGH TEXTURE AND ORGANIC MATTER CONTENT

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Urban green spaces are increasingly valued for their ecological and social benefits, yet urban soils are often heavily degraded, polluted, or structurally unsuitable for vegetation growth. To compensate, natural soils are frequently imported from rural areas—a practice that is both economically costly and environmentally unsustainable. At the same time, large volumes of urban mineral waste remain underutilized. Constructing Technosols—engineered soils made from recycled waste—represents a promising, circular approach to restoring soil functions and supporting urban vegetation. However, optimizing ecological functions based on the properties of parent materials (organic and mineral) and their proportions in the initial mixture remains challenging.

In this study, we investigated how texture and organic matter content influence the functions of constructed Technosols, such as primary production, water infiltration and retention, soil chemical fertility, and carbon sequestration. To this end, we set up an in situ experiment in Louvres (Paris region, France), using excavated mineral materials (EMM) as the main component of the Technosol formulation, combined with 0%, 10%, or 20% sand and 0%, 10%, or 20% green waste compost (GWC). A natural topsoil was also tested as a reference, resulting in ten different treatments arranged in a randomized complete block design with four replicates. In March 2023, each 4 m² plot was seeded with a mix of four grass species to simulate urban lawns. Since then, we have monitored CO_2 fluxes (measured monthly using a Li-COR gas analyzer), soil moisture (TDR probes), and plant coverage. After one year, we measured physicochemical properties (pH, cation exchange capacity, water holding capacity, bulk density, C/N ratio), elemental and molecular composition (via X-ray fluorescence and mid-infrared spectroscopy), microbial abundance (qPCR), diversity (HTS), activity (Biolog EcoPlates), and plant biomass, including spontaneous weeds.

As expected, GWC significantly improved chemical fertility, while sand primarily influenced physical parameters. Sand decreased water retention, especially in the absence of compost, but increased infiltration. The incorporation of sand and compost affected CO_2 emissions, microbial abundance, and activity—although compost additions partly compensated for these changes. Notably, plots with both sand and GWC showed reduced weed colonization and supported a more homogeneous grass cover, suggesting a selective effect on plant community assembly. The integration of organic amendments such as GWC proved essential for maintaining soil fertility, microbial diversity, and primary production, achieving results comparable to those of the natural topsoil. This in situ experiment demonstrated the feasibility of reusing urban waste materials to construct functional soils, thereby promoting sustainable urban development and contributing to circular economy objectives.

GT 13 - 457 - F + P

HEALTHY SOILS, HEALTHY CITIES: ASSESSING SOIL QUALITY IN URBAN GREEN SPACES

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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A wide range of disturbances affect urban soils, including changes in land use, paving and soil sealing, municipal waste disposal, as well as its atmospheric chemical composition, among others. These disturbances manifest in the alteration and degradation of soils and, consequently, of the ecosystem services they provide. Therefore, it is essential to assess soil quality under these disturbed conditions to understand its role in the context of global change.

This study analyzed the relationships of 31 parameters including physical, chemical and biological measured in soil samples from the surface (0-10 cm) and subsurface (10-20 cm) horizons under four plant communities, widely distributed in the urban green spaces in Madrid City. A network analysis was conducted for each horizon. Variables with higher eigenvector centrality values were pre-selected for an initial dataset, and then the SQI was calculated following the methodology of Martin-Sanz et al. (2022).

In the superficial soil layer, variables were clustered into three significant modules. The first module encompassed variables related to the quantity and quality of soil organic matter and the activity of the enzymes related to the C, P and S cycling and N-acetylglucosaminidase. The second module was composed of variables related to nutrients and the urease activity. The third module grouped the parameters associated with the physical-chemical characterization and the arylamidase activity.

In contrast, within the subsurface horizon, cycling coupling was more conserved. Although variables were also clustered into three modules, their distribution differed from the above. The first module comprised variables related to quantity and quality of soil organic matter, enzyme activities and nutrients; the second module clustered a portion of variables associated to physical-chemical soil properties and alkaline-phosphatase enzyme activity; and the third module contained variables regarding Cation Exchange Capacity and particle size.

Network analyses revealed that the surface horizon exhibits a higher disruption of biogeochemical cycles than the subsurface horizon, probably due to the greater exposure to potential perturbances and exogenous nutrient inputs. However, it is necessary to continue studying urban soil quality, as they provide essential ecosystem services to urban populations and are subjected to a wide variety of pressures.

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GT 13 - 738 - F + P

SOILS IN THE CITY: CHEMICAL AND PHYSICAL PROPERTIES OF GREEN AREAS IN MILAN (ITALY), WITH A FOCUS ON COMPACTION

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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This work investigates chemical and physical properties of soils in public green spaces across Milan, with a particular focus on soil compaction, and constitutes one of the first systematic investigations of soils in the city. Soil compaction is widely recognized as a key driver of soil degradation in urban environments, yet the assumption that urban soils are associated with high levels of compaction has been increasingly questioned. This research is part of a wider investigation on urban soils and their ecological functionality, carried out under the PNRR – National Biodiversity Future Center.

Five categories of green areas were selected: lawns of urban parks inside and outside the historic centre, lawns and forests of peri-urban parks and lawns of small urban green spaces. In total, 60 sampling sites were identified. At each site, a 4 x 4 m georeferenced plot was set to carry out soil sampling and soil compaction measurements (bulk density and soil resistance to penetration). Soil was sampled by layers of 0–10, 10–20, and 20–40 cm depth. Bulk density (BD) was measured in the top 5 cm. Soil resistance to penetration (PR) was measured with a field penetrometer up to 40 cm depth.

To explore how soil properties vary in the urban context, linear mixed models including only green area category as fixed effect were applied. To assess the anthropogenic contribution to soil compaction, a more detailed modelling approach was applied only to soil compaction variables (BD and PR): multiple linear mixed models were used, including relevant soil parameters as covariates.

SOC content was generally good and did not differ significantly among green area categories (mean ± sd: 3.2 ± 0.8%, in the 0-10 cm layer). In contrast, pH values varied significantly: peri-urban sites exhibited sub-acidic conditions while central urban parks tended toward neutrality. Available phosphorus also differed, with higher values observed in small green spaces and central urban parks—likely due to fertilization—compared to lower levels in peri-urban areas. Although BD values (ranging from 0.73 to 1.27 g*cm-³) remained well below critical thresholds, differences among green areas reflected the anthropogenic influence on compaction levels, with peri-urban forests showing the lowest (mean = 0.92; sd 0.06 g*cm-³) and central urban parks the highest values (mean ± sd: 1.15 ± 0.12 g*cm-³). Similarly, PR in the top layer (0-10 cm) differed significantly among green area categories, following a gradient of increasing anthropogenic pressure. In deeper layers (10-20 and 20-40 cm), differences were less pronounced, with only forest soils showing consistently lower resistance.

The study reveals substantial variability in soil properties across Milan's green spaces. Although signs of anthropogenic impact are evident, compaction levels remain below critical thresholds, and overall soil conditions are generally favourable—challenging common assumptions about urban soil degradation.

GT 13 - 741 - F + P

ENHANCING URBAN SOIL FUNCTIONALITY THROUGH ORGANIC AMENDMENTS: EFFECTS ON CARBON DYNAMICS, MICROBIAL BIODIVERSITY AND VEGETATION PHYSIOLOGY

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Urban soils, although extensively modified by anthropogenic activities, play a key role in the global carbon (C) cycle through their capacity to store and release carbon. The balance between C fixation and release processes regulated by microbial activity, vegetation, soil physicochemical properties, and topography determines their contribution to climate change mitigation. Sustainable management of these soils can enhance carbon sequestration, improve resilience, and support biodiversity in urban environments.

As part of the National Biodiversity Future Centre (NBFC) project, an experimental study is being carried out in two urban areas of Campania region of Italy, aiming to evaluate the long-term effects of different fertilization practices. Soils were treated with repeated applications of either organic amendments vermicompost (VC), micronized biochar (BC), or their combination (VC+BC) or mineral fertilizer (urea, MIN). Monitoring at multiple time points (T1 and T2) assessed changes in CO_2 and CH_4 emissions, microbial biodiversity, and soil parameters (such as pH, organic matter, nutrient content, porosity, etc.).

In parallel, agronomic and physiological parameters of the vegetation cover were assessed using advanced digital agriculture tools. Biomass was measured in fresh and dry weight; soil volumetric water content and temperature were recorded using sensors; canopy temperature was monitored through thermal imaging; leaf physiological status was evaluated by fluorescence measurements to assess anthocyanins, flavonols, and chlorophyll content. Vegetation indices including Normalized Difference Vegetation Index (NDVI) and Photochemical Reflectance Index (PRI) were also captured.

Preliminary results, based on bimonthly measurements, indicate that the organic amendments BC and VC+BC positively influenced key physiological and agronomic traits of vegetation, promoting greater vigor, reduced stress, and enhanced productivity in both study sites. Microbial communities showed a time-dependent response to fertilization closely linked to soil and vegetation changes. Organic amendments, particularly VC+BC, enhanced microbial diversity, soil stability, and carbon retention with lower respiration rates. Conversely, mineral fertilization increased CO_2 emissions, microbial activity but reduced biodiversity and structural stability. In addition, microbial community composition was influenced by both physicochemical soil properties and treatment; moreover, correlation analysis revealed coordinated behaviour among soil variables, reflecting urban soil response complexity.

These findings support integrated organic management in urban soils as an effective strategy to enhance ecosystem services, biodiversity, and improve resilience to climate change.



GT 13 - 815 - F + P

THE EFFECT OF SOIL MANAGEMENT PRACTICES ON SOIL CARBON STORAGE IN URBAN GREEN SPACES WITH PINUS PINEA

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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Cities are home to more than half of the world's population and, in the context of ongoing climate change, are particularly vulnerable to its impacts. Urban green spaces play a key role in making cities more resilient to climate change due to the ecosystem services it provides. Through photosynthesis, vegetation sequesters carbon, contributing to the removal of carbon dioxide from the atmosphere, one of the greenhouse gases responsible for global warming. In natural ecosystems, the transfer of organic matter from vegetation to the soil leads to soil carbon accumulation, with the soil acting as a crucial component in carbon storage. In urban green spaces, however, this dynamic is typically quite different, as the accumulation of organic matter on the soil surface is often limited due to maintenance practices. The continuous removal of plant residues can limit soil carbon accumulation and reduce its potential as a carbon reservoir.

To investigate how plant residue management practices in urban green spaces may be affecting soil carbon content, we compared three nearby sites where the tree layer consists exclusively of pine trees (Pinus pinea), but with differing and consistent litter management practices over the years: T1 – regular removal of pine needles, leaving the soil bare, without shrub layer; T2 – no pine needle removal, allowing a continuous layer of litter to cover the soil, without shrub layer; T3 – urban forest, with no litter removal and a well-developed shrub layer composed of various species.

We found that T2 had more stored organic carbon than T1, with T3 showing an intermediate value. Furthermore, these green spaces also accumulate carbon in the organic litter layer which is thicker in T2 than in T3, and non-existent in T1.Our findings indicate that, with the adoption of appropriate maintenance practices, urban green space soils can play a more significant role in organic carbon sequestration.

GT 13 - 299 - P

EXPLORING THE ROLE OF URBAN SOUNDSCAPES AND THEIR INTERACTION WITH URBAN LANDSCAPES IN LATIN AMERICAN CITIES

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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In the context of Latin American cities, where accelerated urbanization has intensified socio-spatial inequalities and territorial fragmentation, this study explores how urban soundscapes can reveal symbolic, social, and environmental dynamics related to soil use and transformation.

From a perspective that integrates acoustic ecology with contributions from critical geography and space anthropology, as proposed by Harvey (1991), urban soil is understood not only as a physical resource but also as a social construct shaped by power relations, collective memories, and everyday practices in the configuration of urban inequalities.

The methodology is based on a transdisciplinary approach that integrates theories from critical geography, space anthropology, and acoustic ecology studies. Data collection was carried out through semi-structured interviews with residents from selected urban areas, aiming to explore their perceptions and experiences regarding urban noise. Technically, sound level meters were used to capture acoustic characteristics at strategic points across the city, complemented by registration sheets to document the social and environmental conditions at each location. Additionally, sound maps were created through the collection of acoustic samples in different urban sectors.

Starting with a representative city, selected based on criteria such as accelerated urban growth, social inequalities, and soil fragmentation—common characteristics in many Latin American cities—a comparative analysis was made with other cities from the same geographical region, sharing similar features regarding urbanization and soil fragmentation processes.

The symbolic aspect of noise was analyzed through a qualitative approach, demonstrating how noise serves as a mediator in the social construction of space and the configuration of urban memory, highlighting the tensions between the material and symbolic aspects of urbanization and territorial fragmentation processes.

Results suggest that urban noise is not only a physical phenomenon but also a symbolic indicator closely linked to socio-economic inequality, gentrification, and the displacement of vulnerable communities. In some areas, residents reported that noise becomes a symbol of insecurity and social fragmentation, while in other areas, higher noise levels correspond to accelerated soil transformation processes, such as real estate speculation. These findings suggest that urban noise analysis can provide valuable insights into the underlying dynamics of soil use and urban space reorganization, especially in contexts where public policies have failed to effectively address territorial inequalities.

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GT 13 - 388 - P

IMPACTS OF AGRICULTURAL LAND FRAGMENTATION AND CONSOLIDATION ALTERNATIVES IN ALBANIA

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Albanian agriculture is characterized by small farms and a high level of land fragmentation. Until 1990, agricultural land was considered state property, and farming was managed through 550 production units, which included state agricultural farms and cooperatives, overseeing approximately 700,000 ha of land. After 1991, with the political and economic changes and the land privatization reforms, about 380,000 large and medium-sized family farms were established. However, the land was fragmented to a high degree, with an average of 4.4 undivided plots per person. The land was divided into 1.8 million plots, 180,000-200,000 of which were intended for privatization. These plots, mainly in the plain areas, were subdivided among 15 to 20 owners, or more.

The goal is to analyse the dimensions, disadvantages, and the economic, social, and environmental consequences of land fragmentation at the production level. This includes assessing the infrastructure of the plots, land degradation, fertility decline, land use and packaging, agricultural technology, and investment analysis. About 58% of agricultural farms are smaller than one hectare and consist of 4-5 plots. Moreover, 15-20% of agricultural land at the national level remains uncultivated, often due to small plots located far from residential areas. In 40% of agricultural land, soil fertility has declined, and irrigation efficiency has deteriorated compared to pre-1990 levels. Fragmentation has caused losses of 1-1.5%.

Over the 30 years since privatization, there have been some initiatives by farmers and government support for farm enlargement, land leasing, agricultural associations, and farmer cooperation. However, these efforts have been insufficient to mitigate the impact of fragmentation on land use, protection, and sustainable agriculture.

The main findings on land consolidation and property unification will also be discussed, focusing on legal aspects such as the drafting of the land consolidation law, amendments to the Criminal Code to prevent further fragmentation from the creation of new families, promotion of the land market, and provision of certificates to farmers for farm enlargement and land consolidation. The advantages of innovative land consolidation technologies, as well as methods, forms, and schemes of land consolidation, will also be examined. The study will present principles based on local experiences and market-driven land re-parcelling, in line with the most compatible strategies for sustainable land management.

GT 13 - 587 - P

FROM WASTE TO SOIL: NEWLY CONSTRUCTED TECHNOSOLS FOR SUSTAINABLE URBAN GREENING AND PROTECTION OF NATURAL LAND

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Despite soil being a non-renewable resource essential for life, providing more than 95% of our food production and hosting over a quarter of global biodiversity, its depletion keeps growing, driven by expanding urbanization, infrastructure and commercial developments, often at the expense of valuable natural and agricultural land.1 This ongoing conversion not only threatens food security and ecological integrity but also leads to a shift of fertile soil into urban areas where it becomes sealed, degraded, or contaminated. In response to this challenge, our work explores the possibility of recycling urban land by creating technosols: engineered soils developed from construction and demolition waste (CDW), blended with organic by-products such as compost from municipal organic waste.2 CDW constitutes the largest share of waste in Europe, accounting for 37.5% by mass (800.6 million tons per year), making its recovery and reuse a pressing environmental priority.3 Furthermore, its local availability reduces the environmental impact of long-distance material transport.

An experimental site has been established in the urban area of Chieri (province of Turin, Italy), where different technosol formulations are being evaluated alongside natural soils for their potential to support plant growth. Soils are periodically sampled and analyzed to monitor their development and early-stage pedogenesis, and to assess agronomic, physicochemical, and microbiological properties essential for fertility. Three species of herbaceous perennials were grown on the technosols and monitored for morphological and physiological parameters. Now in its second year, the experiment shows promising results. The transformation of urban waste into functional soil demonstrates potential not only for reducing the consumption of natural land but also for advancing a circular approach to resource use within urban environments.

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GT 13 - 660 - P

EXCAVATED SUBSOILS AS BUILDING BLOCKS FOR FUNCTIONAL TECHNOSOLS IN URBAN GREEN INFRASTRUCTURE

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 09. SOIL HEALTH

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Urban green infrastructure (UGI) projects are nowadays framed as nature-based solutions (NbS), which depend on soils as foundational component for their functionality provision. They can simultaneously sustain vegetation, providing and cycling nutrients, while storing water and carbon (C). Yet, city managers still rely on imported natural soil or sand for UGI, practices that challenge NbS principles of circularity and local resource use. Constructed Technosols, that consist in engineered blends of urban waste materials, offer a sustainable and functional alternative, but research on their multifunctional performance remains limited. In an 18-month mesocosm experiment we compared four Technosol recipes that combined excavated sub-soil (ExS), crushed concrete aggregates, green-waste compost and sand in different proportions. Six ecosystem functions relevant to NbS were quantified from normalised physical, chemical and biological indicators. Primary productivity, nutrient provision, nutrient cycling, water regulation, carbon storage and microbiological habitat quality were assessed. Technosols rich in ExS markedly enhanced four of these functions relative to sand use. Nutrient provision rose significantly ($F = 18.40$, $p < 0.001$) due to the finer texture of ExS that increased cation exchange capacity, total nitrogen, available phosphorus and potassium. Nutrient cycling improved ($F = 18.95$, $p < 0.001$) through higher soil organic carbon, balanced C:N and pH. Water regulation increased markedly by microporosity levels and consequently greater plant available water ($F = 4.62$, $p = 0.013$), key attributes for stormwater buffering in semiarid cities. Carbon storage was the most responsive function, more than tripling with ExS inclusion ($F = 19.49$, $p < 0.001$) as clay content correlated to additional carbon. Primary productivity and microbiological habitat quality did not differ among treatments, suggesting that uniform irrigation masked short-term plant and microbial contrasts. Overall, Technosols that replace sand with local ExS retain nutrients, moderate hydrology and sequester soil carbon without sacrificing immediate plant performance, which align with circularity goals and NbS performance criteria. These findings validate the use of ExS based Technosols as substrates for resilient, climate adaptive urban landscapes.

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GT 13 - 879 - P

FROM THE GARDEN TO THE TABLE: SOIL HEALTH INDICATORS IN ALLOTMENT SOILS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 16. CONNECTING PEOPLE AND SOILS

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Traditionally, it was assumed that urban soils on the whole are of poor quality, storing limited or no soil organic carbon (SOC). However, this has been challenged by research demonstrating that not all urban soils are sealed or degraded to the point of being inconsequential in SOC estimates. Allotment soils, despite occupying less than 0,1% of the surface area in cities, contribute to national C emissions inventories. They would also supply fruits and vegetables to at least 15% of a city's residents if all available urban land were cultivated. Improving soil health is required for sustainable production of quality food in such spots. It is supposed that allotment gardeners consistently employ management practices conducive to high soil quality. Despite its key contribution to human and soil health, management practices in urban areas are poorly known as compared to farmland. The present study aimed at assessing several soil health indicators (biodiversity, SOC, physical and chemical properties) in tilled and non-tilled allotment soils. The study was carried out in 12 urban gardens from Bragança city (Portugal), 6 tilled and 6 non-tilled plots (40 m2 each), over 3 soil types: Regosols (1) clay loam, well-drained and (2) silt loam, poorly drained, and (3) Gleysol, silt loam, very poorly drained. Soil monoliths (30 cm by 20 cm by 20 cm depth) were collected after harvesting in random points inside each plot. Earthworms were screened, counted and weighted for fresh biomass assessment shortly after monoliths collection. From these, 3 soil samples were taken for routine physical (humidity, apparent density and porosity) and chemical determinations (pH, electrical conductivity, macro e micronutrients). Aggregate stability was assessed in wet sieving apparatus. As expected, earthworm abundance was exponentially correlated with soil moisture and aggregate stability, and negatively with heavy metals (Cu). Soil type had a significant effect in aggregate stability, which was 96% (soil type 1), 90% (2) and 93% (3) and earthworm abundance which was 858 (soil type 1), 263 (2) and 467 (3) individuals per area (m2). However, no differences were found by type of management (tilled and non-tilled) at the end of the crop cycle (autumn). Micronutrient contents (B, Cu, Fe, Mn, Zn) were very low, confirming that the urban soils analyzed were not contaminated by human activities. Finally, physical, chemical and biological soil health indicators in allotment gardens mirror those recommended for the maintenance of soil health and organic matter.

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GT 13 - 937 - P

PLANNING AT A CROSSROADS: RECONCILING DEVELOPMENT, NATURE RECOVERY, AND AGRICULTURAL LAND

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 09. SOIL HEALTH

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Over the past several decades, the trajectory of land use policy in the UK has consistently prioritised development and economic growth, often at the expense of agricultural land, biodiversity, and greenfield spaces. Despite the presence of protective frameworks, the planning system continues to favour housebuilding and infrastructure delivery, with the presumption in favour of sustainable development frequently overriding environmental constraints.

This trend stands in stark contrast to the warnings and recommendations of key environmental assessments. The State of Nature Report(1) has repeatedly documented the ongoing decline of UK biodiversity, highlighting the cumulative impact of habitat loss and land-use change. Similarly, the Lawton Review (2) Making Space for Nature called for a fundamental shift in conservation strategy, advocating for “more, bigger, better and joined” spaces for nature to build ecological resilience. Yet, fifteen years on, progress remains limited, and the fragmentation of natural habitats continues.

These reports underscore a growing tension: while policy rhetoric supports nature recovery and sustainable land stewardship, the practical outcomes of the planning system often tell a different story. Agricultural land, including Best and Most Versatile (BMV) soils, continues to be lost incrementally, with greenfield development proceeding in the absence of a clear national threshold.

The introduction of Biodiversity Net Gain (BNG) as a mandatory requirement under the Environment Act 2021 represents a significant shift toward integrating nature recovery into the planning system. With a minimum 10% measurable uplift in biodiversity for all developments (3) , BNG has the potential to deliver long-term ecological benefits and embed environmental value into land-use decisions.

Biodiversity Net Gain (BNG) adds complexity to planning by intensifying competition between land-use priorities. It often requires setting aside land for habitats, putting added pressure on agricultural and greenfield areas especially where development already affects limited Best and Most Versatile (BMV) soils.

Moreover, the requirement to deliver BNG, on-site or off-site, can lead to unintended consequences, such as: The fragmentation of productive farmland to accommodate habitat banks; Increased land value competition between food production, housing, and biodiversity credits and Challenges in long-term stewardship and monitoring.

While Biodiversity Net Gain (BNG) is vital for reversing biodiversity loss, its implementation must support not undermine sustainable land management, food security, and climate resilience. Without a clear national land use framework, BNG risks unintended trade-offs such as the loss of productive land or fragmented habitats. Aligning BNG with the emerging Land Use Framework for England, including soil health monitoring, is essential to ensure ecologically and agriculturally viable outcomes.

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GT 13 - 970 - P

IMPACT OF AGRICULTURAL MANAGEMENT INTENSITY ON ANTIBIOTIC RESISTANCE GENE ABUNDANCE AND MOBILITY IN CAMBISOLS OF THE CONTINENTAL REGION

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 04. SOIL BIOLOGY

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Antimicrobial resistance (AMR) is a major global threat to human and environmental health. Agricultural soils have been increasingly recognized as key reservoirs of antibiotic resistance genes (ARGs)[1]. However, the role of agricultural management intensity in shaping ARG abundance, diversity, and mobility remains poorly understood. This study investigates how different intensities of agricultural management influence ARGs in soils from the German Continental region (Berg-Nideggen).

A total of 30 soil metagenomes were analysed across two sampling dates (November 2023 and April 2024; depth 1-10 cm) under three intensities of maize cropping (2 times in 5 years – high, 1 time in 5 years – moderate, and anytime – low). DNA extractions from 0.3 g of soil were performed using the PowerSoil Pro kit (Qiagen), and long-read metagenomic sequencing was conducted using Oxford Nanopore’s PromethION platform. ARG copies were detected and normalized in count per million (cpm) using the ARGO pipeline2. Statistical analysis and visualizations were achieved using RStudio (v. 2023.09.1-494).

Our results showed that agricultural intensity did not significantly affect overall ARG total abundance. However, rifamycin, beta-lactam, bacitracin, and biocide were consistently among the most abundant ARG classes across all management intensities. ARG genes such as arr, helR, bla, bacA, and sugE were associated with chromosomal DNA. The arr and helR genes, belonging to rifamycin type, which were mainly hosted in the genus Nocardioides, basA as bacitracin type was found mainly in Gaiella and Mycobacterium, whereas bla (beta-lactam type) and sugE (biocide type) were found in Blastococcus. Notably, some ARGs commonly found in mobile genetic elements (e.g., ant(3”)-I, catA, dfrB, erm(A), fosB) showed increased association with plasmids under higher management intensities, suggesting a potential enhanced horizontal gene transfer[3]. However, these genes could not be linked to any host taxa (Unclassified). Previous studies revealed that plasmids have a multi-copy nature and can be shared between different species, which may favour the evolution of ARGs[2].

These results show the importance of monitoring both the abundance and mobility of ARGs in agricultural soils and their implications for the environment and public health. Therefore, there is a need to link soil ecology and antimicrobial resistance to reinforce sustainable soil practices to minimise AMR risk, supporting future models to safeguard ecosystem services under a One Health framework.

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Proportion of antibiotic resistance genes located on plasmids versus chromosomes across management intensities.



GT 13 - 1007 - P

MOWING FREQUENCY AND TRAFFIC POLLUTION AFFECT SOIL MICROBIAL COMMUNITIES OF URBAN ROADSIDE LAWNS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Urban green spaces play an important role in conserving local biodiversity and provide a range of benefits to urban residents. Lawns are a common type of urban green space. They are typically exposed to anthropogenic stressors, such as intensive management and pollution, which usually have adverse effects on biodiversity, soil quality, and the ecosystem services provided.

In this study, we assessed how mowing frequency and traffic pollution (represented by the distance from a road with high traffic volumes) affect soil microbial communities. The experiment was performed at 14 sites in two cities in southern Poland – Katowice and Kraków. Each site consisted of plots with three mowing frequencies: high (six times per growing season), medium (three times per growing season), and low (once, at the end of the growing season). The study lasted for two years. Soil samples (0–10 cm depth) were collected twice, in autumn 2023 and 2024, at two distances from the road (0.5–1 m and 3–3.5 m).

Laboratory analyses included soil microbial biomass measured both as phospholipid fatty acid (PLFA) concentrations (total microbial, bacterial, and fungal PLFAs) and substrate-induced respiration (SIR), and microbial activity represented by soil enzymes.

PLFA-biomass and SIR-biomass were strongly affected by mowing frequency ($p<0.001$). In general, the lowest values of microbial biomass, including bacterial and fungal biomass, were observed in lawns with the highest mowing frequency. The interaction between mowing frequency and study duration was also significant ($p<0.05$) and manifested in much larger differences between mowing regimes in the second year than in the first. PLFA-biomass was also affected by traffic pollution ($p<0.001$); it was generally lower in soils sampled closer to the road edge. Enzymatic activity was mainly affected by traffic pollution; arylsulfatase ($p<0.001$), urease ($p<0.05$), and acid phosphatase ($p<0.05$) activities were lower in soils sampled closer to the road edge.

Our results show that soil microbial communities in urban lawns are negatively influenced by two anthropogenic factors – mowing and traffic pollution. Appropriate management practices, including reduced mowing frequency, are recommended to support the functioning of urban roadside lawn ecosystems.

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GT 13 - 1014 - P

THE EFFECTS OF MOWING FREQUENCY, PROXIMITY TO THE ROAD, AND SEASON ON THE PHYSICOCHEMICAL PROPERTIES OF URBAN ROADSIDE LAWN SOILS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Roadside lawns are one of the most important forms of urban greenery due to the ecosystem services they provide. They often separate vehicle and pedestrian zones, mitigating the negative impacts of the former on the latter. To best fulfil their functions, less frequent mowing is recommended, as this allows for greater plant biomass and diversity, and thus greater efficiency in capturing pollutants from road traffic. Such roadside lawn management may impact the soil environment, but little is known about this.

The aim of this study was to determine whether different mowing regimes affect the soil physicochemical properties of roadside lawns and whether the effect of mowing regime interacts with exposure to road traffic pollution and the season. The study was conducted in two cities in southern Poland, Katowice and Kraków, at 14 sites adjacent to roads with high traffic volumes. Each site consisted of plots mowed at different frequencies: high (six times per year), medium (three times per year), and low (once per year). Soil samples (0–10 cm deep) were taken in spring and autumn 2024 at two distances from the road (0.5–1 m and 3–3.5 m). They were analysed for pH, electrical conductivity (EC), the contents of Cl^- and organic C, and the total contents of Ca, Cr, K, Mg, N, Na, Ni, Pb, and Zn.

Soil contents of Cr, Ni, and Zn were higher in plots with high mowing frequency compared to other plots, with this difference being stronger in spring. Mowing frequency had a different effect on Cl^-, the concentration of which was higher in the soils of the two less frequently mown plots, but only in autumn. The other variables were not affected by the mowing regime. Many variables had higher values for samples collected near the road (pH, EC, Cl^-, Na, Ca, Mg, and Cr). Notably, the first four variables – reflecting winter deicing salt application – showed more pronounced differences between distances to the road in spring. A reverse pattern was observed for K, which was higher in soils sampled farther from the road, especially in autumn.

The results show that less frequent mowing translates into lower soil pollution with some trace metals, probably because better-developed vegetation provides more effective protection for the soil against road dust. There is also a significant small-scale gradient in numerous soil parameters related to the distance from the road. This includes nutrient and xenobiotic contents and may locally impair plant nutrition and the health of the soil microbiome.

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GT 13 - 1040 - P

THE LEGACY OF HUMAN ACTIVITY ON SOIL PHOSPHORUS AND METAL ENRICHMENT: A STUDY OF PRE-COLUMBIAN ANTHROSOLS

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Phosphorus is a key nutrient for plant development and thereby for human population development [1]. The non-renewable nature of P as an agricultural resource and their relevance as agricultural nutrient makes the increasing dependence of P an alarming human concerns [2,3], requiring a higher knowledge about P biogeochemistry in order to optimize the P use. Anthrosols are a special group of soils derived from long-lasting human activities which are characterized by high C and nutrient contents, including P, as a result of differential biogeochemical dynamics when compared to neighboring natural soils [4]. Among those, two Anthrosols derived from pre-Columbian activity, the Dark Earths (DE) [4] and the shellmounds (SH)[5], are especially significant because of their high P content and differential P biogeochemistry.

In this work, 68 samples of these Anthrosols (38 SH, 30 DE) and 7 samples of natural Acrisols were collected in tropical, equatorial and subpolar regions to assess the effect of climate, geology and human activity on P biogeochemistry. Acrisols (pH:4.3±0.3; TOC:5±0.1%; TN:0.03±0.01%) pH and total content on C and N (4.3±0.3; 5±0.1%; 0.03±0.01%, respectively) were significantly lower than those of the DE (pH:5.6±1.6, TOC:1.6±0.6%; TN:0.16±0.18%) and SH (pH:7.2±1.2, TOC:4.3±4.3%; TN:0.24±0.33%). Trace metal content (As, Cd, Co, Cu, Pb, Zn) were higher in Anthrosols than in Acrisols, reflecting the influence of anthropogenic enrichment processes. Additionally, SH soils exhibited consistently higher concentrations compared to DE. Phosphorus content was significantly higher in Anthrosols, which showed a more complex and diverse distribution of P forms than those of Acrisols. This is especially relevant in the carbonate enriched samples where Ca-bound P were overall predominant, excepting of subpolar samples where humic-bound P were predominant. These results emphasize the biogeochemical significance of the edaphic pre-Columbian Anthrosols, which are enriched in P and trace metals and exhibited unique P distribution patterns, pointing out to the significant impact of human pre-Columbian activities on their distinct characteristics, being this especially relevant to differentiate between Dark Earths and shellmounds.

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GT 13 - 1055 - P

ASSESSMENT OF WATER CONSUMPTION IN ALLOTMENT URBAN SOILS IN NORTHERN PORTUGAL

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Urban horticulture, in addition to providing fruit and vegetables to urban residents, is important for ecosystem service provision. It is increasingly viewed by international organizations as a facet of ensuring future food security. Preliminary results, carried out in HARVEST Project, demonstrate that allotment gardening contributes to the Mediterranean diet by increasing the consumption of vegetables and legumes to values close to those recommended by the World Health Organization. However, research on allotment gardens is still scares and, although many agricultural practices contribute to improving soils, the high-water consumption is a disadvantage that queries its sustainability in an urban environment. The aim is to evaluate water consumption in allotment gardens in northern Portugal, in five pilot areas in the cities of Porto, Braga, Vila Real, Mirandela, and Bragança. The study methodology consists of, on the one hand, assessing the crop water requirements of the main summer horticultural crops applied to meteorological data from the stations closest to the pilot areas. In parallel, the soil water balance was determined using the Thornthwaite-Mather equation. On the other hand, a nationwide interview was conducted with more than 240 horticulturists to determine their water use habits, i.e., frequency, time and quantity of water used during the crop grown. The results show that the crop water requirements vary considerably in each pilot area, with the Mirandela orchard requiring the most water (up to 700 mm) and Braga the least (207 mm). On the other hand, the results of the soil water balance show water deficit in the summer months, which makes it necessary to irrigate the garden for 4, 3 or 2 months (from June to September) depending on the study area. However, the survey results show that most growers water 3 or 4 times a week (51%), between 30 and 60 minutes a day (70%), and preferentially use surface irrigation (65%). Surprisingly, pilot areas with lower crop water requirements, such as Braga and Porto, are the areas with the most water consume, due to residents' habits: 85% irrigate more than 5 a week and 80% use surface irrigation. On the contrary, residents of areas with the greatest water needs for crops, such as Mirandela, Bragança, and Vila Real, save more water: 70% irrigate 2-4 times per week. Bragança residents have the most efficient irrigation system (65% drip irrigation). It is concluded that, in addition to citizen science programs, the use of more efficient irrigation systems, such as drip irrigation, would reduce water consumption in urban gardens, which would promote more sustainable and healthy urban soils.

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GT 13 - 1076 - P

FROM SEALED TO LIVING SOIL: ONE YEAR OF MONITORING AFTER DESEALING

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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Artificial soil sealing with impervious materials is a primary factor of soil degradation in Europe. It avoids the natural exchanges of energy, water, and nutrients between soil and its surroundings, impairing several soil functions and ecosystem services provision. Desealing, the removal of the impermeable covering layer, is an important measure to mitigate and compensate soil sealing effects and it is currently used to restore soil permeability and implement green spaces, to enhance urban resilience to flooding and heatwaves.

Desealed soils can quickly restore most of their functions, especially when enhanced with exogenous topsoil, organic or mineral amendments, and suitable vegetation. However, the benefits of desealing and its full potential for soil multifunctionality recovery are a relatively recent topic in soil science research and are still poorly understood. This work, as a part of a wider project and field experiment, aims to present the results of one-year soil monitoring after a de-sealing, with the aim to: (i) compare the different dynamics of pedoclimatic factors (temperature, water and oxygen content) in sealed and desealed soil; (ii) monitor the changes in unsealed soil properties and bacterial communities; (iii) evaluate the results in relation to the application of recycled aggregates (RAs), derived from the paving demolition waste, as soil forming material.

Regarding the analysis of pedoclimatic factors, three distinct soil cover conditions were considered: well sealed soil (S1), sealed soil with partial environmental influence (S2) and desealed soil (plots D1-D4). Desealed soil showed significantly lower temperatures compared to both S1 and S2, especially during summer months (up to 7.2°C cooler). The water content was higher in S2, followed by desealed soil (strongly affected by the weather) and well sealed soil (unaffected by the weather). Oxygen content was significantly higher in desealed soil, except for a summer drop to 9.5% due to an increase in soil respiration.

Regarding soil properties, no significant changes were observed within a year except for an initial and temporary increase of pH, Nitrogen and Carbon, following the application of the RAs. The bacterial community characterization confirms that a high percentage of soil diversity is still unknown. However, the analysis of the most abundant bacterial orders showed their strong dependence on pedological and climatic variables, even if no clear patterns of temporal evolution were observed during the year.

This work demonstrated that de-sealing interventions can reestablish soil, atmosphere and hydrosphere interactions and create favorable pedoclimatic conditions for the restoration of soil multifunctionality and biodiversity. The application of RAs didn't show any adverse effects on the desealed soil, though their long-term effects must be investigated.

GT 13 - 1136 P

INDICATORS OF PEDOGENESIS IN INITIAL TECHNOGENIC SOILS DEVELOPED ON HEAPS OF HISTORICAL POLYMETALLIC ORE MINING IN THE SUDETY MTS., SW POLAND

GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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The remnants of historical polymetallic ore mining in the Sudety Mts. are mine waste heaps that have not been reclaimed, but have undergone natural plant succession. The research aimed to determine the properties and mineral composition of Technosols developed on the heaps to classify them and identify the first indicators of pedogenesis. The study area covered former (mainly 19th century) mining centers in Miedzianka, Radzimowice, and Czarnów, where copper and arsenic ores were mined. Twelve soil profiles were studied. The soils were described and classified according to the WRB soil system (2022). The properties were determined using standard procedures used in soil science, and the mineral composition was determined by X-ray diffraction (XRD) method. The studied soils were classified as Coarsic Spolic Technosols. Their properties varied, although trends were observed in most profiles. The emergence of vegetation caused acidification of the topsoil, which is reflected in decreased pH and increased exchangeable acidity in the topsoil. The second effect was the accumulation of soil organic matter (SOM), visible both in the morphology of soil profiles (formation of O and A horizons) and in the properties (increased TOC and TN, increased sorption complex capacity in the topsoil). The highest magnetic susceptibility in majority of soil profiles was found in the topsoils, and it decreased with depth. This suggests that the progress of pedogenesis on the studied soils probably causes the transformation of mineral phases towards phases with higher magnetic susceptibility. Differences in mineral composition are reflected in soil properties such as pH, content of carbonates, and the content of exchangeable base cations. The increased content of Feox and Alox may indicate the mobilization of iron and aluminum in the BC horizons of some profiles, which indicates the beginning of a more advanced soil-forming process. The properties of the studied Technosols were primarily determined by the properties and mineral composition of the parent material (mine waste). The appearance of vegetation on the spoil heaps initiated pedogenesis. The first indicators of pedogenesis were the accumulation of SOM, acidification in the topsoil, changes in the original chemical and sorption properties, enhancement of the magnetic susceptibility in topsoil, and the mobilization of iron and aluminum in individual horizons. These soils are in the initial stage of pedogenesis. More advanced geochemical and micromorphological analyses will provide more information about their pedogenesis.



GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 14 - 25 - O

ENHANCING SOIL MOISTURE PREDICTION ACCURACY WITH DIGITAL SOIL MAPPING-BASED COVARIATES

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 05. SOIL HYDROLOGY & EROSION

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Identification and utilization of suitable environmental covariates (ECs) play a critical role in improving the precision of mapping soil moisture (SM) spatial and temporal variations using digital soil mapping (DSM) approaches. Hence, the aim of this study is to improve the accuracy of soil moisture prediction by integrating digital soil mapping-based covariates. For this purpose, satellite images and soil characteristics information obtained from ground sampling points were used. In the first step, a DSM model based on a machine learning algorithm was implemented to generate a map of static soil properties including Sand, Silt, Clay, Field Capacity (FC), Calcium Carbonate Equivalent (CCE), and Mean Weight Diameter (MWD) for the study area. In the second step, two conventional and proposed strategies were considered for SM modeling. In the conventional strategy, reflective spectral bands and indices, land surface temperature (LST), radar bands, and topographical properties as common ECs were used. In the proposed strategy, in addition to these, soil static properties including Sand, Silt, Clay, FC, CCE and MWD were also used as ECs. In conventional strategy, the RMSE values in July, and September were 1.71, and 1.23, respectively. In the proposed strategy, these values were improved to 1.45, and 0.91, which indicated a decrease in RMSE of 15%, and 26%, respectively. The improved performance of the proposed strategy can be attributed to the inclusion of detailed soil attributes that capture the variability of soil composition and water retention capacities, which are crucial for accurate SM prediction. For instance, parameters such as Sand and Clay content directly influence soil permeability and water-holding capacity, while FC and MWD provide insights into the soil's physical structure and moisture retention potential. The findings of this study highlight the significant impact of incorporating static soil properties as ECs in improving SM prediction accuracy using DSM techniques.

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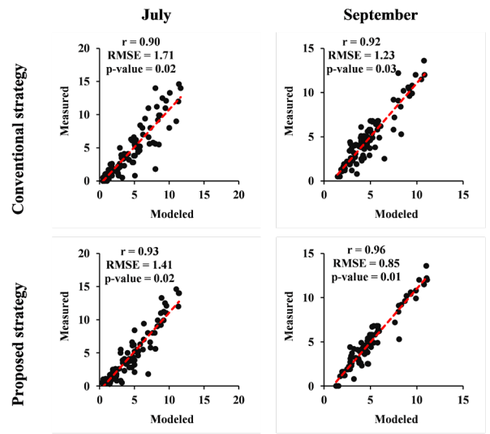
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GT 14 - 39 - O

SPATIOTEMPORAL PREDICTION OF SOIL ORGANIC CARBON DENSITY FOR EUROPE (2000--2022) BASED ON LANDSAT-BASED SPECTRAL INDICES TIME-SERIES

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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The paper describes a comprehensive framework for soil organic carbon density (SOCD) (kg/m3) modeling and mapping, based on spatiotemporal Random Forest (RF) and Quantile Regression Forests (QRF). A total of 45,616 SOCD measurements and various feature layers, particularly 30m Landsat-based spectral indices, were used to produce 30m SOCD maps for the EU at four-year intervals (2000--2022) and four soil depth intervals (0--20cm, 20--50cm, 50--100cm, and 100--200cm). Per-pixel 95% probability prediction intervals (PIs) and extrapolation probabilities are also provided. Model evaluation indicates consistent accuracy, with R2 between 0.53--0.67 and CCC 0.68--0.80 across cross-validations and independent tests. Prediction accuracy varies by land cover, depth interval and year of prediction with accuracy the worst for shrubland and deeper soils 100--200cm. PI validation confirmed effective uncertainty estimation, though with reduced accuracy for higher SOCD values. Shapley analysis identified soil depth as the most influential feature, followed by vegetation, long-term bioclimate, and topographic features. While pixel-level uncertainty is substantial, spatial aggregation reduces uncertainty by approximately 66%. Detecting SOCD changes remains challenging but offers a baseline for future improvements. Maps, based primarily on topsoil data from cropland, grassland, and woodland, are best suited for applications related to these land covers and depths. Users should interpret the maps with local knowledge and consider the uncertainty and extrapolation probability layers. All data and code are available under an open license at https://doi.org/10.5281/zenodo.13754343 and https://github.com/AI4SoilHealth/SoilHealthDataCube/.



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GT 14 - 64 - O

THE SHARING-MED INITIATIVE: STANDARDIZING SOIL SAMPLING METHODOLOGIES FOR IMPROVED AGRICULTURAL SUSTAINABILITY IN THE MEDITERRANEAN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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SHARInG-MeD is a PRIMA project (GA n. 2211) aiming to develop a comprehensive and harmonized soil-monitoring framework and to support environmentally and economically sustainable agricultural practices in the Mediterranean region, with a focus on soil health. To do so, it integrates physicochemical, biological, agronomic, economic, and environmental indicators at the field, farm, national, and regional scales. This initiative also builds on existing soil assessment programs, including LUCAS (EU), Soils4Africa (Africa), and RECSOIL (Global), ensuring compatibility and leveraging overlapping datasets to foster a unified soil database for the Mediterranean and the drylands. The project's core objective is the establishment of standardized protocol for metadata collection and soil sampling, promoting the adoption of consistent methodologies across diverse regions. SHARInG-MeD will compare sampling designs from LUCAS, Soils4Africa, and RECSOIL, harmonizing stratified random sampling for greater accuracy and reproducibility. The SHARInG-MeD sampling strategy complies with both the topsoil (0-20 cm) in Soils4Africa and the LUCAS soil module (0-30 cm), hallowing their harmonization. In addition, SHARInG-MeD sampling will focus in unsampled areas and will be performed in paired land use per site. The project employs a sampling design based on a 2×2 km grid, using Conditioned Latin Hypercube Sampling (cLHS) through various environmental variables. To comply the need of finding two paired land uses the cLHS was undertaken on four times the number of sampling location needed. After the cLHS, a cluster was conducted to find equipotential areas inside each nation and distribute the sampling site among the founded areas. Sampling will take place in Tunisia, Italy, Spain, Algeria, Morocco, Turkey, Croatia, Greece, and France. A key element of the SHARInG-MeD strategy is creating partial overlaps with existing data repositories (and especially LUCAS and Soils4Africa) to promote harmonization and standardization. Thus, SHARInG-MeD welcome collaboration with other projects and local initiatives. This approach ensures consistent and comprehensive soil data collection across diverse geographic and environmental settings. The project seeks to establish a robust soil information system that supports improved agricultural sustainability, environmental resilience, and informed land management decisions.

KEYWORDS

Soil Monitoring, Sustainable Agriculture, Mediterranean Region, Metadata Collection, Standardized Protocols, Soil Sampling Methodologies

ACKNOWLEDGEMENTS

This work was supported by the Partnership for Research and Innovation in the Mediterranean Area ('the PRIMA Foundation') through the "Soil Health and Agriculture Resilience through an Integrated Geographical information systems of Mediterranean Drylands" project (grant agreement number 2211) (SHARInG-MeD).

GT 14 - 122 - O

DO ADVANCED MAPPING TECHNIQUES CORRESPOND TO THE SPATIAL VARIABILITY OF SOIL GLOMALIN?

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 04. SOIL BIOLOGY

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It is well understood that the digital soil mapping (DSM) technique has enhanced conventional soil surveying since the 2000s after introducing the SCORPAN model [1]. Even with limited data, DSM simplifies numerous tasks in the understanding of the spatial variability of hard-to-measure soil biological properties. Most frequently studies beyond DSM belong to Australia, China, Brazil, the United States, France, Germany, and Iran [2]. This paper is extracted from the original research work considered for soil quality assessment (Figure 1). To simplify, only the spatial distribution of soil total glomalin (TG) and easily extractable glomalin (EEG) was addressed for a case study in Sarab County, East Azerbaijan Province of Iran with an area of 30,267 ha. The spatial distribution map of TG and EEG was finally prepared using a random forests (RF) model and solely DEM-derived data for the entire study area. The best accuracy of predictions was found for TG, followed by EEG with a concordance value of 0.27 and 0.23, respectively. It was also found that longitudinal curvature, channel network base level, and potential incoming solar radiation play important roles in predictions. The final digital maps showed a variation among anthropogenic management for the entire study area based on the differences between TG and EEG because TG results from the accumulation of glomalin in soil over years of cultivation, while EEG is the recently produced glomalin. The highest value of TG was found in the central and southern parts of the study area, mainly covered by Festuca and Alfalfa. Further observation illustrated that these areas have a moderate catchment area and high topographic wetness index. The overlaying digital maps with field observations revealed that potato and wheat are the main annual crops containing high EEG. Specifically, TG (in mg/g) was categorized as class I: less than 0.271; class II: 0.271–0.318; and class III: > 0.318 with a mean value of 0.29 mg/g. EEG (in mg/g) also showed that 46%, 39%, and 15% of the study area were classified into class III: > 0.168; class II: 0.141–0.168; and class I: < 0.141, respectively. This research ultimately demonstrated that the DSM technique was successfully applied to digital soil assessment of soil TG and EEG. Although the remotely sensed data did not contribute to the prediction of TG and EEG, it is expected to enhance our findings while those were implemented as dynamic covariates.

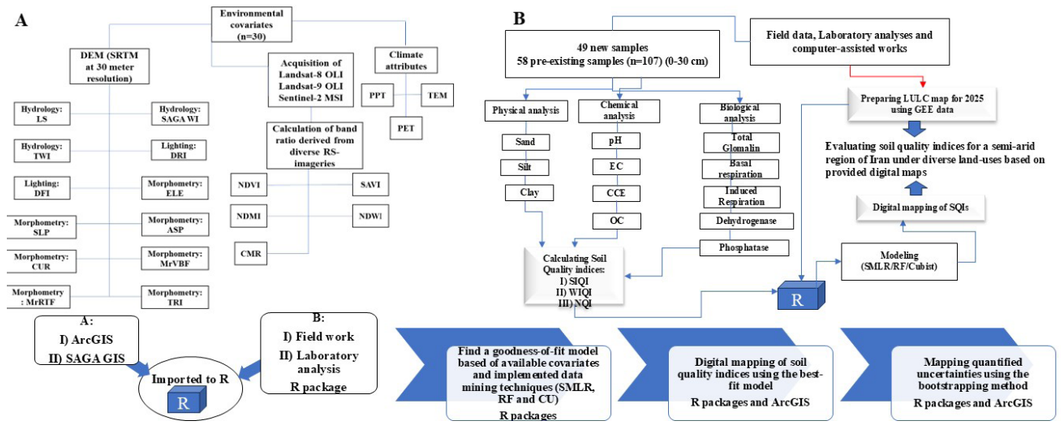
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GT 14 - 139 - O

DETECTION OF SOIL MANAGEMENT PRACTICES USING SENTINEL-1 TIME SERIES: THE CHALLENGES RAISED BY THE DIVERSIFIED MANAGEMENT SEQUENCES IN VINEYARDS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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Characterization of soil management strategies in the complex agroecosystems of vineyards is crucial to evaluate their impact on vineyards soil health, particularly in the context of increasing soil threats posed in semi-arid environments [1], [2], [3], [4]. This study evaluates the potential of Sentinel-1 (S1) radar times series to detect soil management practices in Spanish vineyards. Two trellis-trained vineyards plots (ca. 4 ha each) located in the Toledo province (Spain) were studied, each subjected to a distinct soil management practice: conventional tillage (TILL) and a cover cropping system (CC), respectively. A farmer survey was conducted to thoroughly document the sequence, timing, and spatial distribution of management operations carried out between October 2020 and August 2024. A methodology based on S1 radar signal change detection was applied to detect soil surface roughness associated with these practices. The survey data served as a reference to evaluate the accuracy of the S1-derived detections. Results revealed a very high degree of variability in vineyards management practices, in terms of type, spatial distribution and frequency within these fields. Despite such diversified management sequence, satellite-based detection was effective on average, over more than 60% of the plot surface area, for tillage for both TILL and CC plots, weed control and rolling for only CC plot. Additionally, mechanical pruning was successfully detected in the TILL plot. Our further research will explore the integration of S1 radar data with S2 optical imagery to refine this detection and assessment of soil management practices in viticultural systems.

ACKNOWLEDGEMENTS

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GT 14 - 162 - O

EVALUATING THE UNCERTAINTY OF DEEP LEARNING SOIL SPECTRAL MODELS USING MONTE CARLO CONFORMAL PREDICTION (MC-CP)

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soil spectroscopy, combined with large spectral libraries and deep learning, offers a rapid and accurate method for analysing soil properties. However, a key limitation is the quantification of uncertainty in soil spectral models, which is crucial for informed decision-making. Existing approaches to uncertainty quantification are either computationally intensive or unable to reliably capture the variability of observed data. This study investigates the uncertainty in convolutional neural networks (CNNs) model in predicting soil clay content from the mid-infrared spectroscopy. The model was trained on 39,177 observations derived from the Kellogg Soil Survey Laboratory. A specific method, Monte Carlo (MC) dropout method uses dropout layers in neural networks performs multiple stochastic forward passes to generate prediction intervals. Although efficient, MC dropout often underestimates uncertainty. Conformal prediction, a model-agnostic alternative, provides theoretical guarantees for coverage but assigns a fixed prediction interval, resulting in overly conservative estimates. To address these limitations, Monte Carlo conformal prediction (MC-CP), as introduced by Bethell et al. (2024) [1], was applied. MC-CP combines the strengths of the two methods. The results demonstrated that MC-CP outperformed both individual methods. For the 90% prediction interval, MC-CP achieved a 91% coverage, closely aligning with the expected target and outperforming MC dropout (74% coverage). Moreover, MC-CP produced narrower intervals than standard conformal prediction (22% narrower), avoiding unnecessary conservatism. These findings suggest that MC-CP offers a promising method for integrating a routine robust uncertainty quantification into deep learning-based soil spectral models.

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GT 14 - 169 - O

IMPACT OF IMPROVED SOIL PROPERTIES REPRESENTATION IN THE DYNAMIC GLOBAL VEGETATION MODEL LPJML

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Soils play a major role in supporting terrestrial life by providing multiple regulating, provisioning and supporting ecosystem services. Due to the tight interactions between the atmosphere, the hydrosphere, the biosphere and soils, all major environmental challenges (food security, sustainable energy, biodiversity) are closely dependent on soil health. In order to face these challenges, it is important to assess the role of soils in preserving the health of terrestrial ecosystems at the global scale.

Dynamic Global Vegetation Models (DGVMs) are widely used for studying global-change dynamics of terrestrial ecosystems and biogeochemical cycles. Among DGVMs, LPJmL is the only model that represents dynamic land use, combines natural and managed ecosystems (cropland, pastures and forests) and the full terrestrial hydrology within one consistent modelling framework for biogeochemical cycles. However, even though soils are the largest pools of carbon, nitrogen and freshwater in global terrestrial ecosystem, they are still poorly represented in this model. In fact, soils in LPJmL consist of five layers representing a fixed total depth of three meters, each layer having the same texture and pH properties estimated from measurements in the top layer (0-30 cm).

The objective of this study is to explore the consequences of a better soil properties representation on the performance of LPJmL. To do so, a variable soil depth as well as layer dependent soil properties were introduced in the model. Global soil data were obtained from the SoilGrids v2.0 database.

Both the new and default versions of LPJmL were used to conduct a global historical (1900 – 2019) simulation. Preliminary results show a decrease in the predicted global soil carbon and nitrogen by around 10% while global inorganic nitrogen stocks decreased by around 50%. Global productivity (GPP, rice, maize, grassland) also decreased by around 5%. Spatial distribution of soil organic carbon showed that most carbon storage took place in the boreal permafrost regions (Canada, Russia, and Alaska) followed by the tropical regions. Comparison between soil organic carbon concentrations simulated by the new version of the model and those provided by the SoilGrids database showed an overall overestimation of the simulated concentrations in the top surface layer (0–5 cm). It also showed an underestimation of SOC concentrations in all layers of histosols and gleysols (especially in Scotland and Canada).

These new developments help emphasize the sensitivity of DGVMs to soil representation. For LPJmL, they lay the groundworks for continuing the improvements of soil processes (such as interaction between soil texture, hydraulic properties and SOC decomposition) as well as the introduction of more soil processes that will further improve the model's representation of the complex interactions between all ecosystem components.

GT 14 - 251 - O

EO-BASED SOIL EROSION MAPPING IN ARCTIC REGIONS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 05. SOIL HYDROLOGY & EROSION

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Soil erosion is becoming an increasingly critical concern across Arctic regions, driven by permafrost thaw, shifting precipitation patterns, and land use. Despite this urgency, large-scale and high-resolution erosion risk assessments are still limited, especially in remote areas where on-site monitoring is challenging or inaccessible for much of the year.

This project explores the applicability of a methodology that integrates Earth Observation (EO) data with Machine Learning (ML) techniques to measure and map soil erosion over large Arctic areas with minimal ground-based input.

This approach was developed by Fléttan, an environmental startup based in Iceland, and first implemented in the Icelandic landscape [1]. The resulting model is now being adapted for expansion to other Arctic countries. It combines multi-source satellite data, including Sentinel-2 optical imagery, digital elevation models and land cover classifications with field-validated soil datasets to produce high-resolution maps.

A strong feature of the approach is its adaptability. The pipeline includes automated preprocessing and extraction steps that minimize manual intervention. It can also integrate additional datasets, such as soil carbon maps, vegetation cover, or snowmelt information if available, but can also rely entirely on global satellite data.

The ML models are trained using a hybrid dataset: combining official ground measurements with labeled data derived from areas identified by local agencies. Validation against known erosion features in national maps shows a strong 93% agreement, with the added benefit of scalable automation and flexibility.

To increase the model's applicability, current efforts focus on identifying partners in Canada, Norway, and Greenland to access soil datasets and ground-truth information to support cross-border adaptation. These partnerships aim to build a network of collaborators capable of refining open-source geospatial tools.

Planned extensions include adapting the methodology to monitor additional geohazards, such as soil organic carbon emissions and landslide risk, through the application of the same EO-based framework where supporting datasets are available.

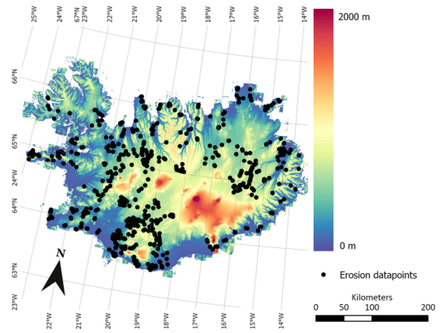
These results show the potential of applying low-cost EO-based systems to deliver insights for soil conservation and climate change monitoring, especially in regions where logistical barriers limit fieldwork. The project aligns with the goals of the EU Soil Strategy for 2030, offering an efficient tool for prioritizing vulnerable areas and informing land management strategies. It also highlights the importance of data sharing and institutional cooperation for advancing international soil monitoring.

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GT 14 - 255 - O

SPECTRAL INDICES IN REMOTE SENSING OF SOIL: DEFINITION, POPULARITY, AND ISSUES. A CRITICAL OVERVIEW

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Serving as a powerful proxy in remote sensing studies, spectral indices can generate meaningful environmental interpretation from either raw or atmospherically corrected spectral data, and characterise and quantify some important properties of various objects on Earth's surface. However, while numerous spectral indices have been developed over time, since the very launch of civilian satellites until now, some critical issues in their usage, such as comparability, remain scarcely studied, which may lead to incorrect, inconsistent, and unreliable results.

In this study, we collected 462 spectral indices of various environment components (vegetation, water, and soil), and traced their popularity in scientific publications over the past decades, with particular focus on soil. The bibliometric analysis revealed a growing interest and utilisation of spectral indices as Earth-observing satellite technology advanced. We discuss the issues of naming confusion, comparability, applicability, accuracy trade-offs, and reproducibility of using spectral indices, based on case studies conducted on regional scale. Overall, this review provides an extensive list of spectral indices, both soil indices and soil-related indices, that can be useful for characterising soils and soil properties by remote sensing. The comparisons between different spectral indices, sensors, and correction methods, highlight the confusing effects that the misuse and non-standardised practices of the spectral indices useful for soil, may have on soil property mapping and monitoring. Insights to the judicious and appropriate usage of spectral indices in the remote sensing of soil are provided.

If possible, the authors would prefer to be considered for Session 14.1 "Soil Data Acquisition, Curation, Sharing & Modelling", with Session 8.1 as an alternative option.

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This work was carried out in the framework of the MELICERTES project (ANR-22-PEAE-0010) of the French National Research Agency (France2030 and national PEPR 'agroécologie et numérique' programmes). It was also supported by the STEROPES project of the H2020 European Joint Programme Cofund on Agricultural Soil Management (EJP-SOIL Grant Number 862695), by the POLYPHEME project of the TOSCA program of the Centre National d'Études Spatiales (CNES) (Grant Number 200769/id5126). Qianqian Chen has received the support of a PhD scholarship from the China Scholarship Council (Grant Number 202206320054). A.C. Richer-de-Forges., E. Vaudour and D. Arrouays are members of the Domaine d'Expertises Scientifiques Theia "Cartographie Numérique des Sols" supported by the CNES, France.

GT 14 - 275 - O

ADVANCING THE REUSE OF LONG-TERM FIELD EXPERIMENTS DATA THROUGH AN OPEN-ACCESS PLATFORM

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 16. CONNECTING PEOPLE AND SOILS

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Long-Term Field Experiments (LTEs) are essential infrastructures, designed to generate consistent, long-duration data on soil, crop, and environmental dynamics, offering crucial insights into the long-term effects of management practices. To address the fragmented nature of LTE-related information across responsible organizations, we developed an open-access online platform featuring an interactive LTE-Map (https://lte.bonares.de) that compiles and enables analysis of metadata from over 600 LTEs worldwide (Grosse et al., 2021; Donmez et al. 2022). The map integrates LTE metadata records from the BonaRes (www.bonares.de) and EJP SOIL (https://ejpsoil.eu/) projects, visualizing LTEs globally by management type, land use, duration, pedo-climatic conditions, and status.

Beyond LTE data collection and management, to support data reuse, we leverage this consolidated (meta)data through geospatial techniques to reveal the impacts of climate change on various soil functions (Donmez et al., 2024; Blanchy et al., 2024; Lachmuth et al. 2025). This process enhances the relevance of LTE research to the community and guides future research directions enabling a better understanding of climate change impacts on agricultural productivity across different regions, addressing key topics of interest such as soil conservation, and carbon balance.

Our freely accessible LTE-Map promotes open science and collaborative research, supporting the development of solutions for sustainable agriculture in a changing climate. By consolidating and reusing dispersed LTE data, it facilitates the scaling up of agricultural practices from site to landscape level, enhancing climate change adaptation strategies for agricultural yield and management. This work complements and extends the efforts of networks (e.g., LTER and GLTEN), offering a global perspective on long-term soil and agricultural research.

ACKNOWLEDGEMENTS

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GT 14 - 293 - O

SPATIAL PREDICTION OF SOIL PROPERTIES USING SENTINEL-2 TEMPORAL MOSAICS OF NON-VEGETATED SOILS IN A SEMI-ARID REGION: A COMPARATIVE EVALUATION OF GOOGLE EARTH ENGINE AND THEIA PLATFORMS IN SMINJA PLAIN, TUNISIA.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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This study investigates the potential of Sentinel-2 (S2) temporal mosaics (TM) of non-vegetated soils for enhancing soil property mapping in the semi-arid Sminja Plain, Tunisia (480 km²). Utilising data from 2019 to 2023 across all seasons (autumn, spring, summer, and winter), we generated TM through the Google Earth Engine (GEE) and THEIA platforms. This comparative evaluation highlighted the importance of platform selection and seasonal considerations in remote sensing-based soil property predictions. Non-vegetated soils were isolated using thresholds of NDVI < 0.35 and NBR2 < 0.09 to maximise non-vegetated soil extraction. Key soil properties analysed through a dataset of 215 sample locations regularly spread over the area included electrical conductivity (EC), soil organic carbon (SOC), pH, base saturation (BS), granulometric fractions, and soil moisture content. Random forest (RF) models with K-fold cross-validation assessed the predictive performance, evaluated using RMSE, RPD, and RPIQ metrics. Results indicate that both GEE and THEIA platforms effectively predicted (with THEIA having a very slight edge) most of the soil properties (SOC, $CaCO_3$, Ca, base saturation, granulometric fractions, and soil moisture content) with RPIQ values exceeding 1.7, while predictions for pH, EC, K, Na, and P_2O_5 were poorly reliable with RPIQ < 0.8. This pinpointed the limitations of the generated RF models for certain soil properties in such environments. Seasonal variations slightly influenced model accuracy, underscoring the importance of platform selection and temporal considerations in remote sensing-based soil property prediction. These findings offer valuable insights for sustainable land management and agricultural planning in semi-arid regions.

ACKNOWLEDGEMENTS

This work was supported by the MELICERTES project (ANR-22-PEAE-0010) of the French National Research Agency, funded under the France 2030 and the national PEPR ‘agroécologie et numérique’ programmes. The authors gratefully acknowledge the financial and institutional support provided by these initiatives, which made this research possible. This study was conducted in collaboration with the University of Paris Saclay, AgroParisTech and INRAE Palaiseau, France, whose expertise and resources were invaluable to the success of this work. We also extend our gratitude to the teams behind the Google Earth Engine (GEE) and THEIA platforms for providing the tools and data necessary for this study. Special thanks to the field teams and collaborators who contributed to data collection and validation in the Sminja Plain, Tunisia. Finally, we acknowledge the Sentinel-2 mission for providing high-quality satellite imagery that formed the backbone of this research.

GT 14 - 312 - O

REGIONAL MAPPING OF SOIL ORGANIC CARBON IN AGRICULTURAL SOILS FROM SENTINEL-2 IMAGERY

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soil Organic Carbon (SOC) is a key indicator soil health and plays a central role in sustainable soil management and adaptation of agricultural ecosystems to climate change. Increasing SOC can also contribute to climate change mitigation by sequestering atmospheric carbon. However, assessing SOC over large areas is challenging, because traditional soil sampling and laboratory analyses are resource-intensive and time-consuming. Remote sensing technologies, particularly high-resolution satellite data from missions like Sentinel-2, have opened new opportunities for large-scale assessment of soil properties, including SOC.

A major challenge in developing models that relate soil reflectance to SOC is obtaining reflectance data from bare soil conditions, which are often limited in agricultural soils due to few bare soil periods and crop residues on soil surface. One approach for increasing the area with bare soil reflectance spectra is to create a temporal mosaic, composed of pixels from multiple dates. The temporal mosaic can be develop using a “per-pixel” approach where each pixel in the final mosaic is selected based on a specific criterion applied across the entire time series.

This study evaluates the potential of using Sentinel-2 imagery to predict SOC in a salt-affected agricultural area in Portugal of about 130 km2. A one-year time series of satellite images was used and a combination of three spectral indices (the Normalized Difference Vegetation Index, the Normalized Burn Ratio, and the Bare Soil Index) was applied in order to extract pixels representing bare soil conditions. After filtering pixels on each image, six per-pixel mosaicking approaches were implemented to analyse which conditions lead to an optimal spectral model: Median reflectance value throughout the time series; 90th percentile reflectance; maximum Bare Soil Index; minimum Soil Water Index; minimum Normalized Difference Vegetation Index; and minimum Normalized Difference Index of spectral bands B2 and B12.

Among the tested approaches, combining maximum Bare Soil Index with a Linear Regression model produced the most accurate SOC predictions, achieving moderate prediction performance (R^2 = 0.52, RMSE = 0.16%). This approach slightly outperformed the application of the 90th percentile of bare soil pixels and the Median approaches with Partial Least Square Regression.

These results also revealed that soil salinity within the observed salinity range of ECe between 1.2 and 10.4 dS m^{-1} in topsoil, did not significantly affect SOC predictions. In contrast, soil texture and moisture content emerged as the dominant factors influencing soil reflectance. This study demonstrates that Sentinel-2-derived indices, can be a cost-effective and scalable solution to monitor and regularly update SOC maps at a regional scale.



GT 14 - 367 - O

IMPROVING THE PREDICTION OF SOIL ORGANIC CARBON CONTENT USING FIELD-ACQUIRED HYPERSPECTRAL DATA BY ACCOUNTING FOR SOIL MOISTURE AND SURFACE ROUGHNESS.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

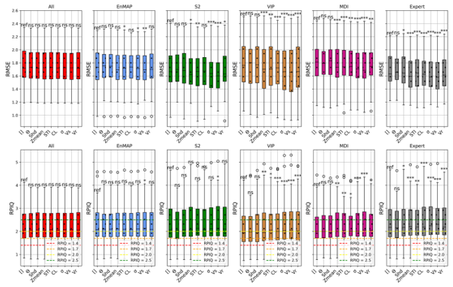
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Soil surface conditions such as moisture, roughness, and vegetation complicate accurate Soil Organic Carbon (SOC) prediction by altering spectral reflectance. Most studies consider these factors separately and under controlled conditions. Soil roughness has rarely been included [1,2], and typically not alongside soil moisture, which has mostly been studied in laboratory settings [3]. Common methods to reduce moisture effects on spectra, such as external parameter orthogonalization (EPO) and direct standardization (DS), rely heavily on lab-based datasets [3]. To address this, we assessed the influence of soil moisture and surface roughness as co-variables in models predicting SOC content from reflectance spectra of bare Luvisols near Versailles, France. Spectral data were collected under natural light at 76 points, along with volumetric soil moisture (θ) and 7 roughness indicators from photogrammetry [4]. SOC was predicted using Partial Least Squares Regression (PLSR) and Random Forest (RF), with 4-fold cross-validation repeated 10 times. Six wavelength-selection (WS) strategies were tested: two from satellite simulations (EnMAP, Sentinel-2), two from model variable importance (PLSR, RF), one expert-based, and one using all wavelengths. Moisture and roughness were added individually. In-field spectra enabled reasonably accurate predictions, with RF outperforming PLSR (SOC RMSE: 1.6–1.8 g.kg^{-1}). WS methods improved accuracy only when co-variables were added. Moisture had little effect, while roughness improved prediction quality in most cases, especially shadow percentage for PLSR and the semivariogram sill parameter for RF. These results highlight the benefit of including surface roughness to improve large-scale SOC prediction from remote sensing.



*Performance metrics (RMSE and RPIQ) for the six methods of wavelength selection and the eight co-variables included for the validation of random forest models. Whiskers indicate 1.5 times the interquartile range from the first quartile and third quartile. Horizontal lines indicate thresholds of prediction accuracy as a function of RPIQ (RPIQ < 1.4: very poor, 1.4 < RPIQ < 1.7: fair, 1.7 < RPIQ < 2.0: good, 2.0 < RPIQ < 2.5: very good, and RPIQ > 2.5: excellent). []: no co-variables included, ?: volumetric soil moisture. See Table 1 for definitions of the other variables, which were related to soil roughness. ns: P > 0.05, *: P = 0.05, **: P = 0.01, ***: P = 0.001. P-values are based on a Student's t-test for each method of wavelength selection, using [] as a reference (ref)*

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GT 14 - 486 - O

INTEGRATING AUTONOMOUS PLATFORMS AND MULTI-GEOPHYSICAL SURVEYS FOR FIELD-SCALE SOIL COMPACTION DIAGNOSIS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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In recent decades, soil quality has declined. One of the factors is soil compaction, mainly due to the use of heavy machinery in conventional farming practices.

Various strategies have been developed to mitigate soil compaction, including controlled traffic farming and special soil management practices.

Nevertheless, quantifying and mapping soil compaction remains challenging, as direct techniques are costly and usually limited to a few point measurements.

This study evaluates the potential of multi-instrument geophysical techniques, combined with direct methods, for identifying and mapping artificially compacted areas.

Compaction was induced by applying a 10-ton load using a tractor (T7 165 S, New Holland – IT) equipped with a four-share plow and ballast, simulating two levels of intensity (moderate and severe) under different soil moisture conditions.

The experiment was conducted on a 0.3-hectare field previously tilled and homogenized, with a split-plot design with three replicates ("blocks"). The splitting factor was the moisture level, being 25% or 30%, while at the subplot level two compactions were compared, "moderate compaction" and "heavy compaction" were obtained with 1 or 5 passes, respectively. The compaction was generated in early April and early May on a silt loam soil with 6% clay, 30% sand and 1.42g/cm3 bulk density.

Using an autonomous rover (Robotti 150D, Agrointelli – DK), simultaneous geophysical surveys were carried out at the end of May when the soil moisture content was around 30%. The rover was equipped with several instruments: a gamma-ray detector (MS-2000, Medusa – NL), a ground-penetrating radar (Stream DP, IDS – IT), an electromagnetic conductivity meter (CMD-MiniExplorer, GF Instruments – CZ), and a cosmic-ray neutron probe (Finapp – IT). Indirect measurements were supported by soil coring down to 1 meter, with analyses of bulk density and texture performed on 10 cm layers.

The results demonstrated the strong potential of geophysical techniques to detect variations in soil physical properties associated with different compaction treatments and moisture conditions. The integration of geophysical approaches with direct measurements proved effective and promising for detecting soil compaction and offers a scalable alternative to more expensive conventional methods for field-scale mapping.





INDEX

GT 14 - 678 - O

DYNAMIC MODELLING OF HYDROLOGY AND SOIL EROSION TO PROVIDE PROCESS-BASED PREDICTORS FOR DIGITAL SOIL MAPPING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 05. SOIL HYDROLOGY & EROSION

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Digital soil mapping (DSM) relates soil data observed at point locations to spatially comprehensive environmental data approximating soil forming factors. These environmental data, such as terrain attributes or satellite imagery, are often obtained at multiple space or time scales, and in a fully data-driven approach, machine learning is utilized to select the most relevant ones. Increasing the predictive performance of these data-driven approaches remains a challenge due to data scarcity and interpretability as the environmental predictors are often derivatives correlating with soil data, but do not explicitly represent the actual soil formation process. A potential alternative explored here is the use of data generated by process-based models. Process-based models simulate spatial soil distribution through replication of pedological processes (e.g. weathering and material translocation), offering explanatory value and applicability in data-sparse areas. Although existing process-based models are considered insightful and informative as they incorporate pedological knowledge, their general parametrization remains challenging and application in DSM remains limited. The integration of process-based and data-driven approaches is regarded as a promising direction for advancing digital soil mapping.

In this study, we used this hybrid approach integrating process-based modelling with data-driven DSM. Specifically, the spatial distributions of a variety of pedological variables were derived from a process-based model and used as a predictor for machine learning based DSM. We tested the approach for the arable land of the Canton of Zurich, Switzerland, where over 3900 samples covering an area of approximately 750 km2 were available. Pedological variables were derived from PyCatch, a dynamic process-based hydrological model that simulates water movement through interconnected stores, modeling properties such as overland flow and infiltration. PyCatch model simulations were run over a time span of 5 years (2015-2020) with starting parametrization from an overview soil map, vegetation data and hourly input of meteorological data. Simulation results allowed to derive spatially explicit DSM predictors describing soil-forming factors (deposition and erosion), soil properties (soil moisture) and their temporal dynamics.

The newly derived predictors were used to spatially predict basic soil properties, such as soil texture, pH, gravel and carbonate content across multiple depths. We benchmarked predictive accuracy with and without the inclusion of these new predictors. Besides, we evaluated interpretability using SHAP values and accumulated local effects plots compared to conventional predictors derived from elevation models or meteorological data. The here presented approach allows to integrate formalized knowledge established in process-based models into DSM and potentially increase model interpretation.

GT 14 - 682 - O

INTEGRATION OF THE EUROPEAN SOIL MONITORING NETWORK LUCAS AND THE STATE-WIDE PEPAC: IMPROVING THE PREDICTION OF SOIL ORGANIC CARBON STOCK IN SPAIN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil organic carbon (SOC) is a major indicator used in public policies for soil health. For this reason, within the European Union at different administration levels, several initiatives are being undertaken to monitor and collect information of this parameter.

At European level this is achieved through the Use and Coverage Area Frame Survey (LUCAS) programme [1], whereas at national level in Spain a soil monitoring network linked to its Strategic Plan of the Common Agricultural Policy (PACCAP) is being implemented [2] (Fig. 1).

Both networks follow comparable sampling schemes, with sub-samples taken crosswise and up to a depth of 30 cm, although the survey designs and laboratory protocols differ. LUCAS follows a stratified random system, while PEPAC is based in fixed grid, and where the sampling density for the country of the former (4,362 plots) is lower than for the latter (15,482). In addition, LUCAS analyses the total carbon content using dry-combustion, whereas PEPAC measures the oxidable carbon content using the Walkey-Black method. By combining these sources and addressing its misalignment, it would allow for better estimation and evaluation of this indicator.

In this research, we integrate the soil monitoring networks LUCAS and PEPAC to improve the characterisation, modelling and mapping of the stock of SOC in Spain. We analysed its effect in terms of survey design: whether the sampling density is uniform across the region, and the optimisation of the monitoring points employed. Next, the laboratory measurements are harmonised using a transfer function between the available organic carbon parameters tailored to Spain. Finally, we generate a SOC prediction model using an Ensemble of Machine Learning algorithms for the whole region.

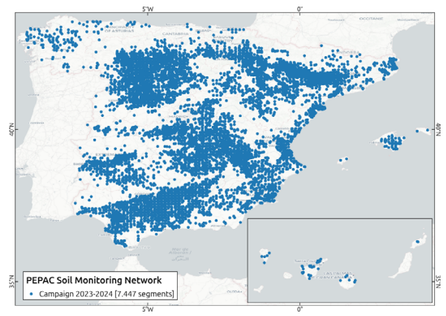
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Plot locations of the PEPAC Soil Monitoring Network across Spain.



GT 14 - 726 - O

FROM GSM-CONFORM PRIMARY SOIL PROPERTY MAPS TO 3D SOIL HYDRAULIC DATABASES AND BEYOND

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 05. SOIL HYDROLOGY & EROSION

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Hungarian Soil Spatial Data Infrastructure has been recently renewed in the frame of DOSoReMI initiative. Countrywide, digital soil property, soil type and functional soil maps were compiled following more or less strictly the GlobalSoilMap specifications. In the meantime high demand emerged on spatially detailed quantitative data regarding soil hydraulic properties to support a range of modeling applications. EU-SoilHydroGrids, which relies on SoilGrids as spatial data on primary soil properties, has demonstrated its utility at the European level. Building on this continental precedent, comparable but larger-scale, 3D soil hydraulic databases have been targeted within the frame of National Laboratory for Water Science and Water Security to be utilized at national and regional/watershed level in Hungary. HU-SoilHydroGrids, has been developed for the whole area of the country at 100 m spatial resolution with several enhancements (compared to EU-SoilHydroGrids) in its elaboration process.

- Pedotransfer functions were developed using advanced machine learning techniques, both independently and as part of ensemble models.
- These models were trained using a national soil hydrophysical dataset, ensuring the derivation of region-specific PTFs.
- The set of predictors utilized in the PTFs was augmented by additional environmental variables.
- To spatially apply the resulting models, 100 m resolution information on primary soil properties was obtained from DOSoReMI.hu.
- Based on a detailed accuracy assessment, the spatial predictions were complemented with co-layers representing the 5% and 95% quantiles.

HU-SoilHydroGrids provides nationwide information on the most frequently required soil hydraulic properties (water content at saturation, field capacity and wilting point, saturated hydraulic conductivity and van Genuchten parameters for the description of the moisture retention curve) at a spatial resolution of 100 meters, down to 2 meters soil depth for six GSM standard layers. HU-SoilHydroGrids demonstrated its improved performance compared to EU-SoilHydroGrids in a number of ways.

A further step toward larger spatial resolution is based on NATASA initiative for the conservation and digital processing of the still available soil observation legacy data originating from large-scale surveys carried out in Hungary between the 60s and 90s. Digitization of the soil observation records is in progress, firstly finalizing for the watershed of the Lake Balaton. The processed area contains almost 40.000 soil observations in the three counties neighbouring the lake, which are used in digital mapping of primary soil properties at a scale of 25 meters. These DSM products then will be similarly adapted as the 100 m resolution DOSoReMI.hu products for the derivation of soil hydraulic property predictions down to 2 meters for six standard GSM soil depth layers, thus providing watershed-level, large-scale 3D Soil Hydraulic Databases (LS-HU-SoilHydroGrids).

GT 14 - 751 - O

ESTIMATING VAN GENUCHTEN MODEL PARAMETERS FROM NEAR-INFRARED SPECTROSCOPY AND THE SOIL WATER SPECTRAL INDEX

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 02. SOIL PHYSICAL CHEMISTRY

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Hydraulic properties of unsaturated soils are essential for understanding hydric functioning and solving flow and mass-transfer problems in the vadose zone. One of the best-known models for representing the experimental soil-water retention curve (SWRC), which describes the matric potential (h) as a function of the water content (θ) of a soil horizon, is the van Genuchten (VG) model [3]. It requires four parameters whose values vary by soil type: residual water content (θr), saturated water content (θs), the inverse of the air-entry pressure (α) and a shape parameter (n). The main objective of this study was to show the relevance of using near-infrared (NIR) spectroscopy to estimate the parameters of the VG model, based on the relation established between the soil water spectral index (SWSI) and θ [2]. Based on this approach, the effective saturation of VG equals the effective SWSI. We applied the approach [1] to 25 soil horizons collected in Brittany (western France) that had high variability in texture and a soil organic carbon content of 0.07-6.23%. The results showed that: i) the NIR-spectroscopy approach was relevant for estimating hydraulic parameters θs, α and n of the VG model, and ii) the parameters obtained from a VG-like equation based on the relation between h and SWSI predicted values of θ of the SWRC that were similar to observed values, with a root-mean-square error of 0.031 and 0.045 cm3cm-3 for topsoil and subsoil horizons, respectively. The method was thus more accurate for topsoil horizons.

ACKNOWLEDGEMENTS

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GT 14 - 789 - O

DIGITAL TWIN OF AGROLANDSCAPE SOILS: A TOOL FOR SOLVING SCIENTIFIC AND APPLIED PROBLEMS.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Digital twins are one of the fastest growing areas in Computer Science, based on the convergence of advanced information technologies, including cyber-physical systems, computer modeling, the Internet of Things (IoT), and several others. However, despite the high potential of the technology, the use of digital twins in agriculture is still at an early stage of deployment (Soderstrom et al., 2016; Tekinerdogan et al., 2020; Verdouw et al., 2020; Sreedevi, 2020). The use of digital twins in agriculture has not yet made a quantitative leap for several reasons. On the one hand, agricultural processes are usually more complex than industrial processes in factories. This complexity is due not only to the high dimensionality of the data, but also to the fact that many variables that determine the behavior of the processes are stochastic in nature and cannot be managed or controlled. In addition, the large area where agricultural processes occur, combined with the heterogeneous conditions typical of these territories, requires spatial and temporal resolution of data, which is technically and economically impossible. The V.V. Dokuchaev Soil Science Institute launched a project to conduct fundamental scientific research and develop a concept and scientific justification for the regulatory and infrastructural support for collecting, processing, analyzing, storing and using data to model processes in soils to create their virtual images (digital twins) when designing agricultural systems. The project developed guidelines, including a standard for describing data and methods for obtaining them, a standard for describing the problems solved by a digital twin of soils, a standard for describing mathematical models for implementing an automated launch, a protocol for describing interaction schemes between data and models to solve problems. The design principles for creating digital twins of soils and soil cover, and the instrumental part of the physical image of the digital twin with the selection of the necessary sensors for measuring the physical and physicochemical state of the soil were developed. The development of a digital twin of soil is based on a digital platform (PaaS, platform as a serveice) for the life cycle of soil and soil cover models, models for processing, analyzing and forecasting the state of soil and soil cover, including neural network models, data sets (collection, storage, marking) and services created on their basis. The platform ensures the use of data received from a set of soil condition measurement sensors (IoT), meteorological data, results of field and laboratory measurements of soil properties, and remote sensing data as information flows. In conclusion, a concept for managing production processes in crop production based on digital twins of soils and soil cover was developed.

ACKNOWLEDGEMENTS

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GT 14 - 833 - O

NATIONAL SOIL SPECTRAL LIBRARY FOR HUNGARY: ESTABLISHMENT AND PROSPECTS FOR SPECTROSCOPY-BASED SOIL ASSESSMENT, CLASSIFICATION AND MONITORING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Spectroscopic techniques, particularly when combined with conventional laboratory analyses, provide rapid, non-destructive, and cost-effective solutions for assessing soil properties. Spectroscopy provides an integrative measure of soil, enabling both qualitative and quantitative information on a wide range of physical and chemical properties to be derived from a single measurement. In this context, we present the development of a country-scale soil spectral library for Hungary—the first in the country to combine visible and near-infrared (VNIR) spectroscopy with mid-infrared (MIR) spectroscopy.

The spectral library was established within the framework of the Agrotechnology National Laboratory project. It is based on archived soil samples collected in 1992 as part of the Hungarian Soil Information and Monitoring System (SIMS). These samples, representing genetic soil horizons of soil profiles from 1236 georeferenced monitoring sites, were previously analysed for key physical and chemical properties, forming a robust reference dataset for spectroscopic calibration.

Measurements were conducted using an ASD LabSpec 4 Hi-Res spectrometer for the VNIR and a Bruker Alpha II FTIR spectrometer for the MIR ranges. This dual-method approach enabled broad spectral coverage, thereby enhancing prediction accuracy and allowing for a more comprehensive characterisation of soils compared to using either method alone. The acquisition protocols followed international harmonisation guidelines set by the Global Soil Laboratory Network (GLOSOLAN), ensuring compatibility with global efforts.

The presentation will introduce the concept, structure and content of the soil spectral library and demonstrate selected applications. These include the development of a soil property estimation service based on spectroscopic modelling; the investigation of the spectral diversity of Hungarian soils; and the integration of spectral data into numerical soil classification frameworks.

By combining archived legacy data with modern spectroscopic tools, this initiative establishes a scalable and sustainable digital soil infrastructure for Hungary. It contributes to strengthening national soil monitoring capacity while aligning with broader European and global efforts toward open, standardised, and digitally accessible soil data systems. Moreover, it supports the implementation of the EU Soil Monitoring Law, which aims to ensure regular, harmonised assessment of soil health across Member States.



GT 14 - 846 - O

OPTIMIZING N_2O EMISSION PREDICTIONS: A META-ANALYSIS COMPARING PROCESS-BASED MODELS ACROSS SUB-SAHARAN AFRICAN SOILS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Nitrous oxide (N_2O), a potent greenhouse gas, contributes significantly to climate change, with agricultural soils being a major source. In sub-Saharan Africa (SSA), increasing fertilization to boost productivity is expected to elevate N_2O emissions, however data scarcity and regional variability challenge accurate predictions. This study compares results from literature on three process-based models (DNDC, DayCent, and APSIM) for simulating soil N_2O emissions, focusing on their input data requirements and predictive accuracy under SSA conditions. Using literature-derived datasets and model documentation, we evaluated each model's ability to simulate key nitrogen fluxes (e.g., nitrification, denitrification) and assessed their data needs (e.g., soil properties, climate, management practices). Results indicated that models like DNDC and APSIM, with moderate data requirements, can offer robust predictions for data-scarce regions. DayCent and APSIM provide comprehensive flux simulations but require extensive calibration. These findings highlight trade-offs between model complexity and applicability in SSA, where data availability often limits detailed simulations. Our comparison provides a framework for selecting appropriate models based on regional data constraints and research goals, supporting climate-smart agricultural policies. Future efforts should focus on integrating remote sensing data and standardizing datasets to enhance model performance in understudied regions like SSA. Therefore, we are currently in the process of calibrating the CN-model [1] with data sourced from an arable site (Oensingen) in Switzerland, to ensure precise simulation of nitrogen fluxes at the Oensingen site. Moreover, we are using QUINCY [2] and the CN-model for SSA datasets, which were compiled in a meta-analysis by Agredazywczuk et al., 2025 (in preparation).

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GT 14 - 84 - F + P

USING DATA FUSION OF FOUR PROXIMAL SENSORS TO DIAGNOSE HORIZONS AND CLASSIFICATION CATEGORY OF ANDISOLS IN TAIWAN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Volcanic ash soils originate from volcanic materials and cover approximately 0.84% of the land surface [1]. In U.S. Soil Taxonomy, these soils are classified as Andisols if they exhibit andic soil properties in at least 60% of the thickness within 60 cm of the soil surface [2]. The identification of andic soil properties requires soil organic carbon (OC) content < 25% and meet the following requirement: bulk density (Bd) ≤ 0.9 Mg/m³, phosphate retention (Pret) ≥ 85%, and a sum of oxalate-extractable aluminum and half oxalate-extractable iron (Alo + 0.5Feo) ≥ 2.0%. However, the conventional methods for analyzing andic soil properties rely on wet chemistry, which are destructive, time-consuming, labor-intensive, and generate chemical waste. In contrast, dry chemistry methods offer a non-destructive, efficient, and waste free alternative. In recent years, proximal sensing, a dry chemistry method, has been increasingly utilized to investigate soil genesis [3], such as visible and near-infrared spectrometer (Vis-NIR), portable X-ray fluorescence spectrometer (pXRF), NixPro color sensor, and magnetic susceptibility (MS) meter. This study aims to integrate data from four proximal sensors (Vis-NIR + pXRF + NixPro + MS) with machine learning to develop predictive models for estimating andic soil properties. A total of 98 horizons from 25 profiles were analyzed. With the combination of Vis-NIR + pXRF + MS, Bd model (RPD = 1.59, LCCC = 0.72) and OC model (RPD = 3.79, LCCC = 0.96) exhibited moderate (1.4 < RPD < 2.0) and good (RPD > 2.0) performance, respectively. Regarding Pret and Alo + 0.5Feo models, moderate performance was achieved using data fusion of Vis-NIR + pXRF. These findings demonstrate that integrating data fusion of proximal sensors with machine learning can be a promising approach for facilitating the classification of Andisols.

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Data fusion	Bd[a]				Ln(OC)[b]				Ln(Al_o+0.5Fe_o)[c]				P_{ret}[d]			
	R^2	RMSE	RPD	LCCC	R^2	RMSE	RPD	LCCC	R^2	RMSE	RPD	LCCC	R^2	RMSE	RPD	LCCC
Vis-NIR	0.45	0.14	1.36	0.64	0.75	0.40	1.89	0.80	0.01	0.40	0.97	0.06	0.36	7.74	1.24	0.56
pXRF	0.50	0.13	1.45	0.66	0.79	0.36	2.12	0.87	0.51	0.28	1.37	0.56	0.18	8.99	1.06	0.29
NixPro	0.41	0.15	1.29	0.60	0.82	0.32	2.36	0.89	NA[e]	NA	NA	NA	NA	NA	NA	NA
Vis-NIR+pXRF	0.53	0.13	1.48	0.68	0.91	0.24	3.14	0.94	0.59	0.26	1.51	0.69	0.52	6.48	1.48	0.68
Vis-NIR+NixPro	0.49	0.14	1.38	0.63	0.87	0.27	2.84	0.93	0.12	0.36	1.08	0.25	0.32	8.04	1.19	0.52
Vis-NIR+MS	0.48	0.14	1.36	0.62	0.82	0.35	2.17	0.85	0.09	0.37	1.03	0.23	0.26	8.57	1.12	0.49
pXRF+NixPro	0.47	0.14	1.36	0.66	0.90	0.23	3.23	0.95	0.41	0.32	1.21	0.41	0.28	8.30	1.15	0.39
pXRF+MS	0.53	0.13	1.49	0.68	0.77	0.36	2.08	0.87	0.47	0.28	1.36	0.57	0.37	7.98	1.20	0.45
NixPro+MS	0.48	0.14	1.39	0.64	0.84	0.31	2.45	0.90	0.08	0.42	0.92	-0.11	0.00	11.19	0.85	0.01
Vis-NIR+pXRF+NixPro	0.59	0.13	1.54	0.69	0.90	0.23	3.28	0.95	0.47	0.29	1.33	0.52	0.37	7.59	1.26	0.59
Vis-NIR+pXRF+MS	0.61	0.12	1.59	0.72	0.93	0.20	3.79	0.96	0.57	0.27	1.43	0.63	0.33	7.98	1.20	0.56
Vis-NIR+NixPro+MS	0.32	0.16	1.22	0.53	0.89	0.25	2.99	0.94	0.12	0.36	1.08	0.25	0.35	7.97	1.20	0.55
pXRF+NixPro+MS	0.35	0.16	1.22	0.56	0.89	0.24	3.14	0.94	0.42	0.30	1.27	0.51	0.45	7.61	1.26	0.48
Vis-NIR+pXRF+NixPro+MS	0.59	0.13	1.52	0.68	0.90	0.23	3.28	0.95	0.47	0.29	1.33	0.52	0.35	7.93	1.21	0.53

[a] Bulk density.
[b] Natural logarithm of organic carbon.
[c] Natural logarithm of sum of ammonium oxalate-extractable Al and half Fe.
[d] Phosphate retention.
[e] Not available.

Table 1 Testing set performance of Cubist models for predicting andic properties with data fusion of different proximal sensors.



GT 14 - 136 - F + P

DOES SURFICIAL SOIL COLOR ENHANCE THE ACCURACY OF SOIL SAND CONTENT PREDICTIONS AT TWO STANDARDIZED DEPTHS?

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 02. SOIL PHYSICAL CHEMISTRY

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Sand fraction among the fine-earth fractions helps to promote better root penetration and allows for aeration and nutrients. Hence, finding the spatial and vertical distribution map of sand content at the topsoil (0-25 cm) and subsoil (25-50 cm) for decision making is valuable. The successful contribution of the surficial soil color (0-10 cm) in addition to climate, DEM-derived, and various remotely sensed data was evaluated. This research indicates the performance of the “S” attribute of the SCORPAN model in predictions. Fifty-five soil profiles and 15 augers took 254 samples in early August 2023 from a 4365.68 km2 area in northwestern Iran. First, soil sand content was measured on the whole samples, and then a spline function was fit to create the data at two standard depth interval ranges following the GlobalSoilMap protocol [1]. Three synergies were evaluated based on environmental covariates implemented to prepare the digital soil sand content maps using the extreme gradient boosting (XGBoost) tree model. The procedure of this research is fully described in Figure 1. The best prediction resulted when using the covariates set on the synergy II, indicating the contribution of DEM, climate, and band ratios derived from Landsat-9 OLI. Specifically for the topsoil, with no soil color contribution, the concordance values for synergies I-III were recorded as 0.07, 0.06, and 0.01, respectively. The RMSE was also 15.26, 15.37, and 15.97, respectively. After the contribution of surficial soil color, the concordance values increased to 0.30, 0.42, and 0.19, while RMSE decreased to 14.5, 13.27, and 15.11. This research justified that the Landsat 9 mission improves the capabilities of Sentinel-2A MSI and even Landsat 8 [2]. A similar trend was observed for the subsoil. Overall, the final digital maps of soil sand content for topsoil and subsoil were prepared using an XGBoost tree model combined with the covariates in Synergy II across the study area. Subsequently, if the clay maps at the two standardized depths are prepared, soil texture could be mapped through fine-earth fraction contents based on different classification systems. i.e., USDA, FAO, and even Australian versions. This work shows insight into shifting digital soil mapping from science to practice and the performance of soil color in addition to static and dynamic environmental covariates in mapping soil texture class.

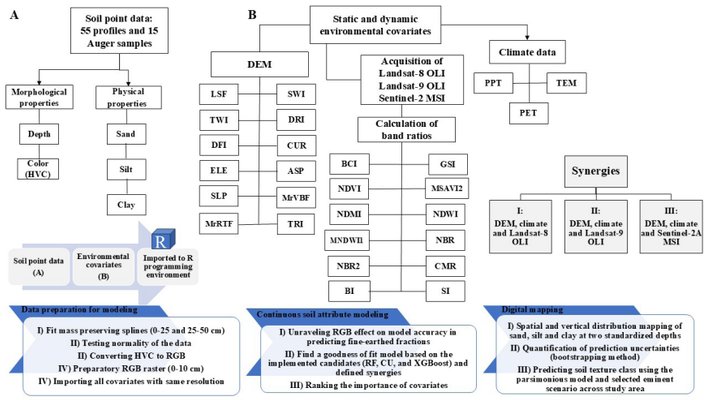
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GT 14 - 600 - F + P

COLLECTION AND HARMONIZATION OF LEGACY SOIL DATA TO SUPPORT DIGITAL SOIL MAPPING IN SICILY (SOUTHERN ITALY)

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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The demand for information on soils and their main properties is increasingly important for applying methods that are becoming available to support research in the field, decision-makers and stakeholders. This demand for information and data is not limited to a few isolated points but concerns the spatial dimension at different scales. Unfortunately, it frequently happens that the availability of such data does not exist and that even if one wanted to start soil survey campaigns, the economic resources for them are lacking. In this context, any kind of data or cartography of the soil from the past, albeit in different formats and qualities, is of great importance and deserving of some kind of exploitation. These data, which collectively can be called legacy data, require harmonisation processes and evaluation of their accuracy in order to be used correctly and effectively. In Sicily (southern Italy), decades of soil surveys and studies have produced a large but incomplete set of data. Moreover, often this data is paper-based maps, from various sources and collected with heterogeneous standards and different depths (topsoil or whole soil profiles). Despite this, the great value of this legacy data is confirmed that even in important databases such as the World Soil Information Service (WoSIS) Soil Profile Database of the ISRIC, just 47 soil profiles with a density of 0.0018 per square kilometre fall in Sicily. This study was aimed at making a systematic review of potential Sicilian soil legacy data and their harmonization in the scope to be used in digital soil mapping. In this study, the results of the activities conducted so far are reported for the creation of a harmonised Sicilian legacy database in which the accuracy of the data was also quantified or in some way evaluated. We focused on compiling information from soil profiles sourced from national and regional institutions, digitising paper manuscripts in university archives and retrieving information on SCOPUS and WEB of Science databases as well as grey literature. Particular attention was given to the diversity of the aim of sampling, depth, year, analytical procedures and spatial support. Actually, more than 3,000 soil profiles corresponding to more than 7,000 soil layers have been. The legacy database will be critical to support advanced digital soil mapping, to foster data reusability, and to provide informed decision-making in land and resource management.



GT 14 - 817 - F + P

PRECISION AGRICULTURE IN SILVOPASTORAL SYSTEMS: A CASE STUDY FROM THE MONTADO (PART I – CONE PENETROMETER APPLICATIONS)

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The Montado is a distinctive silvopastoral system of the Southern Iberian Peninsula, integrating pastures, trees (typically cork oak, Quercus suber, and/or holm oak, Quercus rotundifolia), and domestic livestock (ruminants or swine). Precision Agriculture (PA), predominantly explored in purely agricultural systems, offers substantial potential to optimize Montado management, thereby enhancing its economic, environmental, social, and cultural sustainability. Given the inherent high spatial heterogeneity within Montado plots, the deployment of PA technologies capable of detecting such variability is crucial for informed, site-specific management. Among these technologies are soil compaction sensors, notably the electronic cone penetrometer, which provides the Cone Index (CI) – a key metric for soil physical quality.

During the 2021/2022 agricultural year, a holm oak Montado plot (area = 20 ha; location: Mitra/University of Évora), grazed by cattle under a rotational system (0,6 Normal Head/ha), was monitored at 24 distinct points (12 under tree canopy influence and 12 in open pasture, outside canopy influence). Significant correlations were established between CI and soil moisture content. Regarding the effect of animal trampling on soil compaction, this was found to be significant outside the tree canopy at all assessed depths (0-0.10m; 0.10-0.20m; 0.20-0.30m). Conversely, under the tree canopy, significant effects of trampling were confined to the uppermost 0-0.1m soil layer. Significant differences in CI were also observed according to sampling date, whereas overall plot-level effects (beyond the specific tree canopy vs. open area comparison) were not significant. Unsurprisingly, locations with higher animal congregation, indicative of preferential resting or transit areas, exhibited greater CI values. Instances where CI exceeded 2500 kPa – a widely recognized threshold indicative of mechanical impedance restricting root growth for many agricultural crops – were infrequent. The prevailing precipitation during the study year, which amounted to approximately two-thirds of the long-term average (mean 1994-2024 = 600 mm), likely attenuated the adverse impact of animal-induced soil compaction on the productivity of these rainfed pastures.

The principal findings underscore that soil compaction in these silvopastoral systems is a dynamic and complex process, influenced by an interplay of factors including tree presence, animal behaviour, and temporal soil moisture variations. This complexity warrants the extension of such detailed investigations to other soil types and Montado configurations. Furthermore, there is a clear justification for conducting similar trials over longer evaluation cycles. Such longitudinal studies are essential for the robust calibration and validation of these PA technological tools, ultimately empowering farm managers with more precise data for enhanced decision-making and sustainable land stewardship.

GT 14 - 22 - P

COMPARISON OF SOIL PROPERTY PREDICTIONS IN LITHUANIAN CROPLANDS USING UAV, SATELLITE, AND EMI DATA AND MACHINE LEARNING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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Soil plays a key role in nutrient cycling, carbon storage, and regulating runoff and infiltration, helping mitigate climate change and reduce flood risks. Key indicators of soil health, such as soil organic carbon (SOC), texture, pH, and water content, influence soil fertility, nutrient availability, and other essential processes. However, conventional soil surveys relying on local sampling and laboratory analysis are labor-intensive, limiting coverage and often failing to capture natural spatial and temporal variability. To address these limitations, combining remote and proximal sensing data with machine learning (ML) algorithms has been proposed to enhance soil property characterization and assess spatial variability across different scales (Castaldi et al., 2019).

In this study, we evaluated the effectiveness of seven modeling scenarios: (1) UAV only, (2) EMI only, (3) Sentinel-2A only, (4) UAV + EMI, (5) UAV + Sentinel-2A, (6) EMI + Sentinel-2A, and (7) UAV + EMI + Sentinel-2A. These scenarios were used to predict SOC, soil texture, pH, and soil water content across five agricultural fields located in different agroclimatic zones of Lithuania. A total of 388 topsoil samples (0–20 cm depth) were collected using a regular 20 × 20 m grid across five fields, each ranging in size from approximately 3−5 ha.

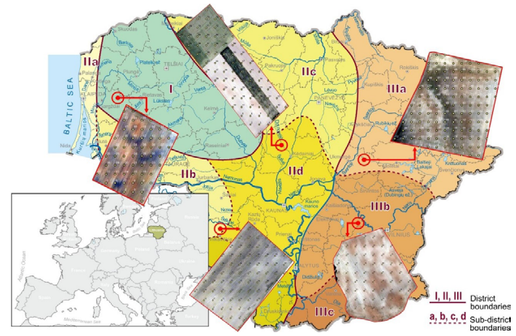


Fig 1. The five selected study sites

The soil dataset was split into 70% for training and 30% for validation. Soil properties for each field were modeled separately based on their characteristics. Random forest models were developed in R using the “Caret” package (Kuhn, 2008).

Modeled soil properties from different data inputs were reasonably well predicted during training. However, prediction accuracy significantly decreased during validation. For example, in SOC prediction, R^2 values ranged from 0.74 to 0.97 during training but dropped to a range of 0.02 to 0.87 during validation.Summarizing all study sites and modeling scenarios, the ranking of soil properties based on prediction accuracy is as follows: SOC ≈ Clay > Sand ≈ SWC ≈ Silt > pH. However, only SOC and clay were predicted accurately, while other soil properties showed very poor prediction performance. In some study sites, better results were obtained, primarily influenced by soil property variability in the fields.

ACKNOWLEDGEMENTS

This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-MIP-24-106.

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GT 14 - 26 - P

AGRICULTURAL LAND SUITABILITY ASSESSMENT USING THE OWA MULTI-CRITERIA DECISION-MAKING MODEL

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Agricultural land suitability assessment is a key tool for sustainable natural resource management and increasing agricultural productivity. This study presents a scenario-based conceptual model for assessing agricultural land suitability using ground sampling data, satellite imagery, and machine learning methods. Soil property maps, including organic carbon (OC), electrical conductivity (EC), and pH, were prepared. Additional criteria considered included soil properties (soil class, geology, erosion degree), topographic factors (slope, elevation, hillshade, aspect, morphology), climatic factors (climate class, precipitation, soil moisture, drought index), and accessibility factors (proximity to rivers, roads, and built-up areas). The Ordered Weighted Averaging (OWA) model was applied to assess suitability under very optimistic, optimistic, neutral, pessimistic, and very pessimistic scenarios. The percentage of high-suitability agricultural lands in the study area decreased significantly from 52% under very optimistic conditions to 5% under very pessimistic scenarios. The weights of soil properties, topography, climate, and accessibility were calculated as 0.3, 0.27, 0.25, and 0.18, respectively. These findings demonstrate that combining environmental data and multi-criteria decision-making models can effectively guide sustainable agricultural land management under varying conditions.

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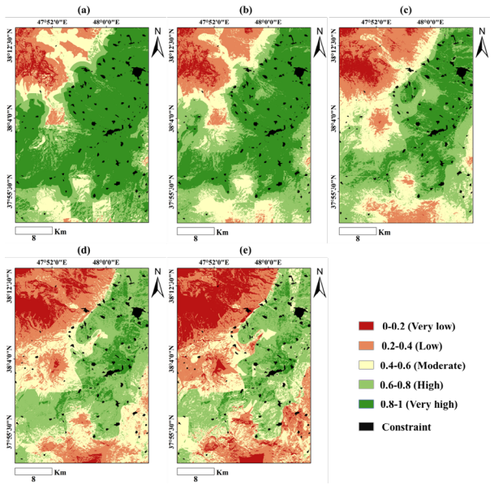


Figure 1. Agricultural land suitability classes based on (a) very optimistic, (b) optimistic, (c) neutral, (d) pessimistic, and (e) very pessimistic scenarios.

GT 14 - 35 - P

GEAGROW: A MOBILE TOOL FOR SOIL NUTRIENT PREDICTION AND FERTILIZER OPTIMIZATION USING ARTIFICIAL NEURAL NETWORKS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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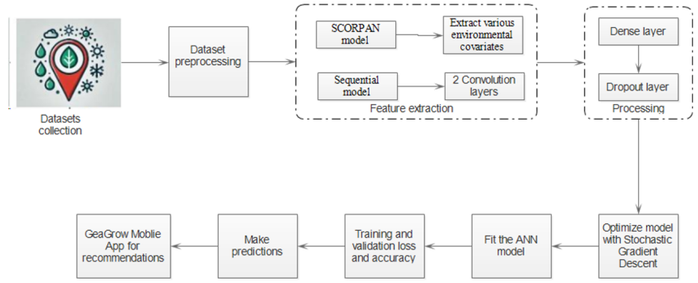
Most farmers in Nigeria lack knowledge of their farmland’s nutrient content, often relying on intuition for crop cultivation leading to improper fertilizer application, which can degrade soil and ground water quality. Traditional soil nutrient analysis requires soil sample collection and laboratory analysis; a tedious and time-consuming process. Digital Soil Mapping (DSM) leverages Machine Learning (ML) to create detailed soil maps, helping mitigate nutrient depletion. Despite its growing use, existing DSM-based ML methods face challenges in prediction accuracy and data representation. This study presents GeaGrow, an innovative mobile app that enhances agricultural productivity by predicting soil properties and providing tailored fertilizer recommendations for yam, maize, cassava, and rice in southwest Nigeria using Artificial Neural Networks (ANN). Primary soil samples were collected from the six states in southwest Nigeria and were analysed in the laboratory to compile the primary dataset mapped to the coordinates. A secondary dataset was compiled using iSDAsoil’s API for data augmentation and validation. The two sets of data were preprocessed and normalized using Python, and an ANN was employed to predict soil properties – Nitrogen, Phosphorus, Potassium, Organic Carbon and pH levels through regression analysis. The model’s performance yielded a Mean Absolute Error (MAE) of 1.9750 for NPK and Organic Carbon prediction, and 0.1029 for pH prediction. The results highlight the effectiveness of digital soil nutrient prediction for NPK, Organic Carbon and pH to optimize fertilizer application. The GeaGrow app provides farmers with accessible, location based soil insights and personalized crop recommendations, marking a significant advancement in agricultural technology in Nigeria. The GeaGrow app also provides smallholder farmers with scalable, ease of adoption of the developed mobile application. This research demonstrates the potential of ML to transform soil nutrient management and improve crop yields, contributing to sustainable farming practices in Nigeria.

KEYWORDS

Digital soil mapping, Fertilizer optimization, Machine learning, Mobile application, Precision farming, Soil data analytics

ACKNOWLEDGEMENTS

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Flow diagram of the developed mobile digital soil mapping application

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GT 14 - 69 - P

ASSESSING SOIL MOISTURE VARIABILITY: A REMOTE SENSING APPROACH IN THE PARANGALITSA RESERVE (2015–2024)

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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This study looks at the spatiotemporal variability of the Soil Moisture Index (SMI) over the period 2015–2024, focusing on the environmental factors that influence how soil moisture is retained and distributed. It explores the roles of land cover, slope, and aspect, while also considering the impact of vegetation and climate conditions on soil moisture dynamics. The goal is to identify key factors contributing to soil drying and erosion risk, offering insights into areas more vulnerable to degradation. Understanding these patterns is important for developing adaptive land management strategies that support soil health, water conservation, and long-term ecosystem stability. The proposed model is flexible and allows for integrating additional spatial datasets, making it useful for ecosystem monitoring, early-warning systems, and sustainable resource management. Using remote sensing, this approach provides a data-based foundation to support better decision-making in soil and forest conservation.

ACKNOWLEDGEMENTS

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GT 14 - 80 - P

HIGH RESOLUTION ACCURATE MASS SPECTROMETRY AS A MEANS OF CHARACTERISING, DIFFERENTIATING, AND LINKING SOILS OF FORENSIC INTEREST.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Discriminating between soils can provide compelling evidence for crime-scene investigations where the transfer of soil from the environment to items of forensic interest has occurred. Soil contains an ultracomplex mixture of organic compounds with thousands of chemically distinct structures and functionalities, influenced by organic matter, liquids, living organisms, and prevailing environmental conditions (e.g., pH, temperature, pollution, etc.). These complex mixtures can serve as chemical fingerprints, making them valuable in forensic investigations where determining the geographical origin of soil is crucial.

This study focuses on method development for forensic soil discrimination using lipid analysis and direct infusion high-resolution accurate mass spectrometry (DI-HRAM-MS). Various solvents and ionisation modes were tested to refine the methodology. Principal component analysis (PCA) based on discriminant lipid entities successfully yielded separable clusters.

While GC amenable lipids have previously been useful for forensic applications, this approach has notable limitations, including (i) extensive sample pre-processing, (ii) long analysis times (over an hour per sample), and (iii) potential shifts in compound retention times across runs. To overcome these challenges, this research explored DI-HRAM-MS as an alternative, rapid, and high-throughput method for soil characterisation. Unlike GC-based techniques, DI-HRAM-MS requires minimal pre-analytical processing and provides data in just a few minutes using only the m/z and abundance domains.

This research tested the overarching hypothesis that DI-HRAM-MS offers a more efficient and accurate approach for soil discrimination compared to traditional methods. By systematically evaluating different extraction solvents and ionisation modes, we demonstrated that negative mode ionisation provides clear and consistent clustering of soil samples through PCA. These findings highlight the potential of DI-HRAM-MS as a robust method for forensic and environmental investigations, enabling the differentiation of geographically distinct soils with minimal sample preparation and significantly faster analysis times.

ACKNOWLEDGEMENTS

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GT 14 - 102 - P

OBSERVATION-BASED MODEL FOR FLEXIBLE AND INTEROPERABLE SOIL DATA SHARING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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There are several data repositories that attempt to collect and share soil data. They try to strike a balance between two important aspects: The flexibility of the data collection (i.e., the degree of freedom authors have to publish data in different formats, formalized or not) and the homogeneity of the repository data (i.e., the degree to which the data within the repository is harmonized).

Some repositories use a flexible approach (BonaRES [1] and EDI Repository [2]), resulting in a very heterogeneous database and limited navigation. Others implement a rigid data structure (LUCAS [3] and Edaphobase [4]), resulting in a system of limited scope with high requirements or costs to integrate new data.

The techniques they propose limit integration and interoperability between soil datasets. In addition, some repositories do not record (or do not require to record) how the data was collected, nor do they propose methods to verify that a particular process was followed while collecting the data. This negatively affects the reliability of the available data.

All of this poses a major challenge to increasing knowledge in the field of soil science by combining and correlating data from different sources. Ways to improve the interoperability of soil data are needed.

We propose a flexible yet formalized architecture for soil data repositories: A data model based on the concept of observations of properties over entities following a specific metric. Our model extends previous proposals for more flexible databases, such as the Entity-Attribute-Value Model, the Entity-Attribute-Value with Classes and Relationships Model [5], and the Universal Data Model [6].

We present the components of our model, along with examples of possible applications. We compare our model to existing architectures, explaining its differences.

Our proposed model seeks to address the current consistency challenges of soil datasets and repositories. It offers methods for researchers to acquire the appropriate data for their studies with minimal transformation. It also provides a medium for sharing individual observations with integrated authorship, formalized process description and verifiability.

ACKNOWLEDGEMENTS

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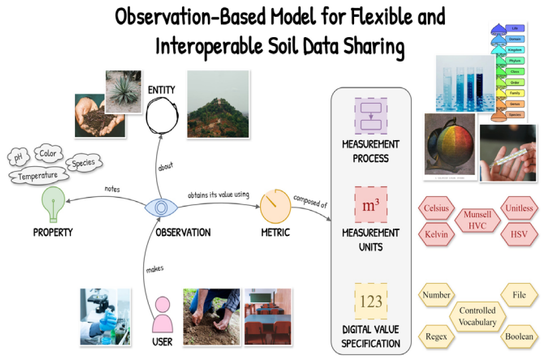
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Simplified diagram for the Observation-Based Model, with examples included

GT 14 - 106 - P

OPTIMIZED SPECTRAL PREPROCESSING AND FEATURE SELECTION FOR ACCURATE SOIL PROPERTY MODELLING WITH PLSR.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soil samples from Morocco were examined using mid-infrared (MIR) spectroscopy, a non-destructive, eco-friendly, and cost-efficient technique for soil analysis. This study investigates the impact of different preprocessing methods and variable selection approaches on enhancing the accuracy of Partial Least Squares Regression (PLSR) models for predicting soil properties, including Total Nitrogen (TN), Total Carbon (TC), Total Organic Carbon (TOC), and textural components such as Clay, Silt, and Sand. These soil properties were predicted using Raw data, Standard Normal Variate (SNV), Savitzky–

Golay smoothing (SG Smoothing), Savitzky–Golay 1st (SG1D), and 2nd (SG2D) derivatives, and the combination of SNV+SG1D, SG-1D+SNV, SNV+SG2D, and SG2D+SNV. The best preprocessing in terms of prediction accuracy was selected to apply variable selection methods (Interval-PLS, Variable Importance in Projection, Selectivity Ratio). The findings indicated that combining Savitzky–Golay derivatives with Standard Normal Variate (SNV) provided the most effective preprocessing approach for predicting most of the studied soil properties. For example, the prediction accuracy for total nitrogen improved significantly, with the coefficient of determination (R^2) increasing from 0.82 to 0.88 and the root mean square error of cross-validation (RMSEcv) decreasing from 0.03% to 0.02% when using SNV+SG2D instead of raw data. After implementing the variable selection technique, the prediction accuracy for most soil properties improved, achieving higher R^2 values and lower RMSEcv, particularly with interval-PLS. While other selection methods also enhanced the prediction of certain properties, they did not lead to improvements for all. Integrating the optimal preprocessing approach with the most effective variable selection method significantly boosted the predictive performance of soil properties.



GT 14 - 108 - P

SOYBEAN (GLYCINE MAX) CROPLAND SUITABILITY ANALYSIS IN SUBTROPICAL DESERT CLIMATE THROUGH GIS-BASED MULTICRITERIA ANALYSIS AND SENTINEL-2 MULTISPECTRAL IMAGING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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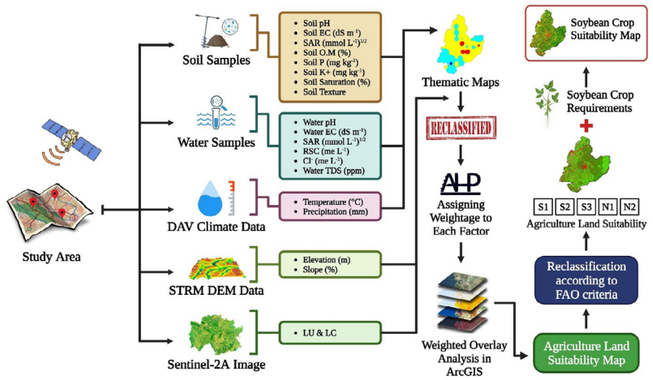
Soybean (Glycine max) is a protein-rich oilseed crop that is extensively used for cooking oil and poultry feed and faces significant challenges due to adverse global climatic conditions aggravated by the ongoing climate crisis. In response to this critical issue, this study was initiated to assess suitable zones for soybean cultivation, aiming to facilitate informed land use decisions within the semi-arid terrestrial ecosystem. Through the utilization of geostatistical interpolation, data layers encompassing soil, irrigation water, land use and land cover, topographic features, and climate information were generated and overlaid based on criterion weightage derived from the Analytic Hierarchy Process. The accuracy of land use and land cover was rigorously evaluated, yielding a 70% overall accuracy and a Kappa (K) value of 0.61, signifying an acceptable level of precision. Validation through the Receiver Operating Characteristic curve for soybean crop suitability demonstrated a highly satisfactory area under the curve of 0.738. The study estimates that out of 172,618.66 hectares, approximately 47.46% of the land is highly suitable (S1) for soybean production, followed by 21.36% moderately suitable (S2), 11.91% marginally suitable (S3), 7.00% currently not suitable (N1), and 12.28% permanently not suitable (N2). Conclusively, the findings suggest that the study area exhibits conducive climatic conditions, optimal soil health, and access to quality irrigation water, all of which have the potential to support soybean crops with improved agronomic practices. This investigation offers valuable insights to both farmers and policymakers concerning irrigation water quality, agricultural productivity, and soil degradation.

ACKNOWLEDGEMENTS

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Graphical Abstract

GT 14 - 109 - P

CLUSTERING SOIL PROPERTIES FOR PRECISION FERTILIZATION ZONES IN OLIVE ORCHARDS USING UNSUPERVISED LEARNING METHODS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Reducing inputs (fertilization, irrigation, pesticides, etc.) while sustaining the productivity of cultivated areas is a significant challenge in the agricultural sector. One of the most widely used practices to address this is delineating soil management zones. This study is poised to bring optimism to the field by evaluating the potential of three distinct unsupervised machine-learning methods for delineating management zones in olive tree cultivation. For this study, 3 fields were selected in the Region of Western Greece, where olive trees are cultivated. The first one (Field 1) is located at Stamna of Aitoloakarnania (38°29'44.9"N 21°17'24.9" E), and 2 more are at the prefecture of Ilia, Vartholomio-Vranas (Field 2) (37°52'30.2"N 21°09'52.4" E) and Geraki (Field 3) (37°47'30.4"N 21°23'47.5" E). The variety cultivated in Field 1 is 'Kalamon', and in Fields 2,3 is 'Koroneiki.' A high-density soil sampling strategy (21 x 21 m) at 0-30 cm depth was conducted. The number of soil samples collected was 101 in Field 1, 61 in Field 2, and 60 in Field 3. Then, the physical and chemical properties of the soil samples were analyzed, namely, soil texture, pH, Soil Organic Matter (SOM), CaCO3, Electrical Conductivity, CEC, as well as the soil content in macro (N, P, K, Ca, Mg) and micro (Fe, Zn, Mn, Cu) nutrients. Principal Component Analysis (PCA) implementation followed data analysis to select the key soil properties for delineating management zones. Three Machine Learning methods (K-means, hierarchical clustering, DBSCAN) were used to delineate management zones. The parameter silhouette score was used to evaluate the machine learning methods. Then, ANOVA analysis was used to identify statistical differences between the delineated management zones. According to PCA, CEC-K-Ca and Clay-SOM-CaC03 are the best-suited soil properties for delineating soil management zones in the studied fields. In Field 1, all machine learning methods delineated two management zones using CEC-K-Ca and Clay-SOM- CaC03. In Fields 2 and 3, K-means delineated one management zone using CEC-K-Ca and two management zones using Clay-SOM-CaC03. Hierarchical clustering and DBSCAN methods delineated two management zones using the PCA-selected soil properties. Based on the silhouette score in Field 1, Hierarchical Clustering was best suited for delineating management zones using Clay-SOM-CaC03, while DBSCAN was the best using CEC-K-Ca. In Fields 2 and 3, K-means was the best method using Clay-SOM-CaC03, while using CEC-K-Ca, the best method was DBSCAN in Field 2 and Hierarchical clustering in Field 3. Statistical significant differences in the properties were identified among the management zones based on ANOVA analysis. In conclusion, this study provides valuable insights for the agricultural sector. It demonstrates that soil management zones can be effectively delineated using unsupervised machine learning methods in olive tree cultivation. Principal component analysis can be employed to select the most relevant soil properties to delineate management zones. The identified soil properties, CEC-K-Ca and Clay-SOM-CaC03, can delineate management zones in olive tree cultivation. The best clustering method, as determined by the silhouette score, varies among the studied fields and the properties used to delineate management zones. This information equips professionals with the knowledge to apply different amounts of fertilizers, such as K, in various management zones, optimizing their use.

ACKNOWLEDGEMENTS

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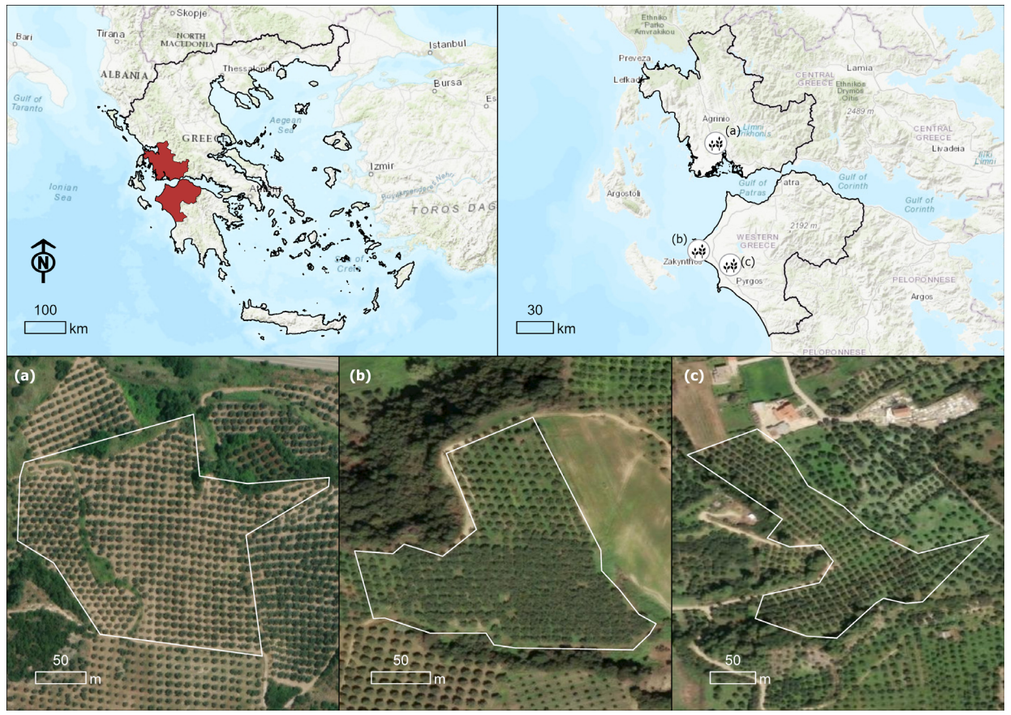


Fig.1. Pilot olive orchard fields in Western Greece



GT 14 - 141 - P

TOWARDS A SOIL SPECTRAL LIBRARY FOR MANITOBA, CANADA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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Reliable and readily available soil information is essential for land managers to be able to make sound and sustainable decisions to build resilient and productive agro-ecosystems. Measuring and monitoring soil properties is expensive, time-consuming, and produces chemical waste. The costs of analyses can quickly become prohibitive for farmers and land managers, obligating them to lower the number of soil samples they collect for analyses and thus worsening the quality of the data on which they base their land management decisions. We will use soil sensors to create information cheaply, quickly, and cleanly. Proximal soil sensors shine electromagnetic radiation (i.e., light) at the soil and the resultant data are interpreted with advanced statistical techniques. There are no chemicals used in the analyses of soil samples with soil proximal sensors, so the process is greener in that there are no waste products to be disposed of as there are for traditional wet chemical analyses. The aim of this work is to incorporate soil property data from commercial laboratories into soil spectral libraries. We propose to combine near- (NIR) and mid-infrared (MIR) (ThermoFisher iS50 FT-IR with XT-Br On-Axis Beamsplitter (11000-375 cm-1)) data to build soil information that can be used to make predictions on soil properties. Approximately 500 soil samples were taken from research sites across southern Manitoba, Canada and analyzed for nitrate-N, ammonium-N, total N, ACE protein, water extractable organic N, water extractable total N, water extractable ammonium N, soil organic matter, soil organic carbon, calcium carbonate equivalent, CO2 burst, permanganate oxidizable carbon, water extractable organic C, pH, salts, Olsen P, K, S, sand, silt, clay, and H3A P, H3A organic P, H3A K, H3A Ca, H3A Mg, H3A Na, H3A Fe, H3A Al, and H3A Zn. These data will be integrated into spectral libraries for the agricultural region of Manitoba that include approximately 25,000 soil samples. Techniques such as machine learning will be used to build prediction models of these soil properties based on IR spectral data. The aim is to build digital tools for land managers to develop resilient agro-ecosystems and to expand the soil properties that can be predicted with soil IR spectroscopy.



GT 14 - 183 - P

DEVELOPMENT OF THE CANADIAN PRAIRIE SOIL SPECTRAL LIBRARY

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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There is a lack of critical soil information such as soil organic carbon (SOC), total nitrogen (TN) and soil texture at high-resolution temporal and spatial scales due particularly to cost and time, which is a major obstacle to long-term sustainable soil management. Soil spectroscopy using visible-near infrared (Vis-NIR) wavelengths has been effectively used to fill gaps in soil data, by rapidly providing quantitative and qualitative analyses. These analyses are dependent on carefully constructed soil spectral libraries (SSL) from local to global scales to derive, via modelling, critical soil information. However, there is a significant gap in SSL development in Canada, including the Canadian prairies. Here, we describe the development of the Canadian Prairie Soil Spectral Library (CPSSL), the first regional SSL in the Canadian Prairies, and some preliminary modelling outcomes. The CPSSL was initiated with legacy soil data from various studies including long-term field experiments in different geographic regions. Legacy soil data was examined to identify and select soil samples to encompass spatial and temporal variability, as well as a diversity of soil and crop management practices, and to identify and fill gaps in metadata and soil information for agricultural land ranging from annual crops to perennial rangeland. Harmonization and curation of the soil data were subsequently performed, including re-analysis of legacy soil samples with up-to-date methods where applicable. Soil spectra were acquired under laboratory conditions on air-dried and sieved (< 2 mm) soils in the Vis-NIR region (350 – 2500 nm) according to internationally accepted standards, ensuring accuracy and reproducibility. Currently, the CPSSL contains 7, 518 soil spectra (Figure 1) from the three Canadian prairie provinces. Preliminary results showed that the CPSSL can be used to predict SOC under contrasting management practices at a local site, as well as across soil zones at regional scales. The CPSSL will provide the ideal opportunity to obtain rapid and cost-effective estimates and monitoring of soil properties, and gain further insights into the impacts of biotic and abiotic factors on Canadian prairie soils. Hence, the CPSSL will help to fill soil data gaps and improve accessibility to critical soil information on the Canadian prairies.

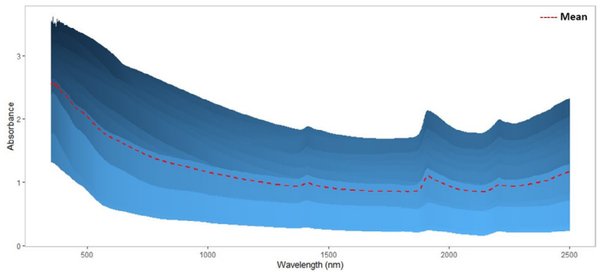


Figure 1. Absorbance of all the soil samples currently included in the Canadian Prairie Soil Spectral Library (n = 7, 518).

GT 14 - 193 - P

REFINING SOC STOCK ESTIMATION IN STONY SOILS: MASS VS. VOLUME CORRECTIONS AND IMPLICATIONS FOR MOISTURE DYNAMICS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Although rock fragments are free of soil organic carbon (SOC), they may influence C stock calculations indirectly by affecting bulk density and potentially modifying microclimatic conditions (e.g., shading, surface cooling), which could alter organic matter dynamics.

This study evaluates the influence of rock fragments on C stock estimation in two vineyards located in Spain (90 ha in Burgos and 190 ha in Toledo). SOC, bulk density, and rock fragments were measured considering 60 composite topsoil (10 cm) samples per vineyard. We compared three approaches for C stock: (i) M1, ignoring rock fragments, (ii) M2, correcting using their mass proportion, and (iii) M3, correcting using their volume proportion, as recommended by the FAO (2020). The objective is to identify which method best correlates with soil moisture.

The two study sites differ notably in their soil composition. The Burgos site, with higher rock fragment content (26% by mass; 19% by volume), has a lower mean SOC concentration (1.06%) compared to Toledo (1.33%).

The coarse fraction in Burgos significantly influences SOC stocks. When uncorrected (M1), C stocks averaged 14.6±5.6 t C ha^{-1}, increasing slightly with correction by rock fragment mass (M2: 15.4±6.2 t C ha^{-1}), but decreasing when corrected by volume (M3: 11.5±4.3 t C ha^{-1}).

A similar trend is observed in Toledo, though less pronounced due to lower rock content (8% mass; 5% vol.): M1: 18.3±6.4, M2: 20.7±7.3, and M3: 17.4±6.1 t C ha^{-1}. Results highlight that C stocks are consistently lower when the volume of rock fragments is considered, especially in coarse soils.

Results revealed differences in C stock estimates and their relationship with soil moisture depending on rock fragment content and correction method.

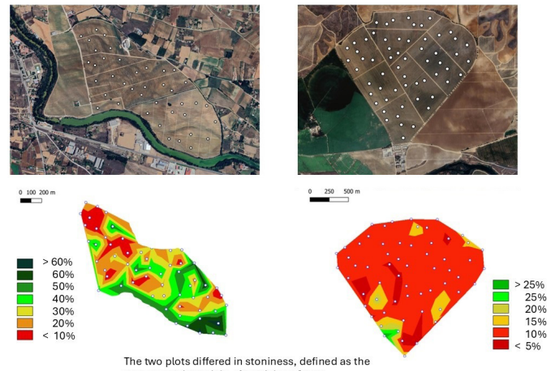
In Toledo (low rock content), C stock estimates showed moderate to strong correlations with soil moisture, particularly in winter (r=0.55) and autumn (r=0.48), with minimal differences between correction methods. In Burgos (coarser soil), uncorrected C stocks (M1) showed no significant correlation with moisture in any season. However, applying a mass-based correction (M2) improved correlations, especially in spring (r=0.61) and autumn (r=0.37). Volume-based correction (M3), which yielded the lowest C stock values, resulted in weaker correlations and may not adequately capture moisture–carbon dynamics in stony soils. These findings suggest that mass-based correction (M2) may be the most consistent approach for such conditions, maintaining a stronger relationship between C stocks and soil moisture—an essential factor for guiding land management strategies aimed at improving water retention in semi-arid environments.

ACKNOWLEDGEMENTS

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The two plots differed in stoniness, defined as the percentage by weight of particles >2 mm



GT 14 - 211 - P

SOIL MANAGEMENT AND ABANDONMENT DETECTION IN MEDITERRANEAN OLIVE GROVES UNDER CLIMATE STRESS: A CASE STUDY FROM CENTRAL SPAIN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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In many Mediterranean semi-arid regions, like central Spain (La Alcarria), rainfed olive groves are increasingly being abandoned due to drought, low profitability, and rural depopulation. The long-term effects of abandonment on soil health remain unclear: while it may foster vegetation recovery, it can also exacerbate degradation on vulnerable soils. Meanwhile, a few pioneering farmers are adopting low-disturbance practices that allow spontaneous vegetation to grow beneath olive trees. These cases provide valuable ground-truth comparisons of ecological outcomes under contrasting management.

We study two key aspects: 1) the impact of olive grove management—tillage vs vegetation cover—on soil health, and 2) the long-term ecological dynamics of abandoned groves and their effects on soil. We combine field data with remote sensing and AI-based land-use classification to assess changes across space and time.

Key soil health indicators assessed include Soil Organic Carbon (SOC), the Normalized Difference Vegetation Index (NDVI), and the Moisture Index (NDMI). Vegetation cover was quantified using a grid point intercept method applied to images processed with SamplePoint software. Field assessments are complemented by a land-use monitoring framework, which integrates abandonment detection through a time series of historical orthophotos (1956–present). A custom-trained YOLOv8 model—previously validated on Italian vineyards—is employed to classify active and abandoned olive groves from aerial imagery. Long-term NDVI analysis offers further insight into vegetation dynamics post-abandonment.

Abandoned groves with unregulated vegetation can be reliably detected through remote sensing. Ground-truth data indicate that in semi-rewilded olive groves, soils are significantly improved—e.g., Soil Organic Carbon (SOC) reaches 1.0% under cover compared to 0.4% in tilled soils; at 30 cm depth, 0.8% vs. 0.2% ($p < 0.05$)—with, importantly, no reduction in soil moisture. These findings suggest that the remote detection of abandonment or low-disturbance management may serve as a proxy for identifying areas of ecological improvement or degradation, supporting more targeted land-use monitoring in semi-arid agroecosystems.

The olive grove owners report high olive oil quality under vegetative cover, enabling access to niche markets and higher prices, and potential economic benefits alongside environmental gains. This study highlights the ecological and agronomic value of spontaneous vegetation in olive groves. It demonstrates the effectiveness of combining soil data, satellite analysis, and AI to evaluate land-use change.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the collaboration of the owners of Olivares La Común (Guadalajara) and the funds from EJP Soil (Grant Agreement No.862695 SANCHOSTHIRST), by the European Union - NextGenerationEU, Mission 4 Component 1.5 - ECS00000036-CUP F17G22000190007 and Confagricoltura Pavia, Sezione Vino, and PNRR's NODES Spoke6VINO.

GT 14 - 216 - P

ASSESSING SPATIO-TEMPORAL PREDICTION OF SOIL ORGANIC CARBON STOCKS UNDER CLIMATE EXTREMES IN SUBTROPICAL AND TROPICAL CATCHMENTS USING MACHINE LEARNING

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Accurate projections of soil organic carbon (SOC) under climate change are critical for guiding regional land management and climate mitigation strategies. This study integrates digital soil mapping with CMIP6-based climate projections to estimate the spatial and temporal distribution of topsoil (0–30 cm) SOC stocks across subtropical (Zhuoshui River) and tropical (Laonong River) watersheds in Taiwan. Using 1377 soil samples and 18 environmental covariates, SOC stocks were modeled at 20 m resolution through Cubist and Random Forest algorithms, combined with regression kriging. The Cubist-based kriging model achieved the best performance ($R^2 = 0.48$; RMSE = 0.42) for SOC stock prediction. Results further show that forested mountain regions hold the majority of SOC (>80%), with tropical zones storing significantly less carbon than subtropical ones. Under future emission scenarios, SOC dynamics exhibit spatial divergence: SSP1-2.6 predicts a 9–21% decline in SOC due to reduced moisture and temperature-driven decomposition, while SSP2-4.5 and SSP5-8.5 suggest localized increases (up to +14%) in forested regions via enhanced productivity. Extreme climate indices (e.g., CDD and R95p) strongly correlate with SOC trends—prolonged drought and intense rainfall reduce carbon stability through microbial bursts, leaching, and erosion. Topography and land use significantly influence SOC vulnerability, with sloping terrains exhibiting higher susceptibility to erosion-induced carbon loss. These findings emphasize the need to incorporate spatial climate indicators and land use into SOC modeling frameworks. The approach offers a transferable method for forecasting soil carbon responses under future climate extremes in ecologically sensitive regions.

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GT 14 - 286 - P

EVALUATING THE RELIABILITY OF IN-SITU SOIL PH AND ELECTRICAL CONDUCTIVITY SENSORS IN VARYING SOIL MOISTURE CONDITIONS FOR REAL-TIME MONITORING.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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Soil pH and electrical conductivity (EC) are critical indicators of soil health, influencing biogeochemical processes and fertility. While traditional laboratory methods are reliable, emerging in-situ sensors offer potential for more efficient and real-time soil monitoring. The relationship between soil water and laboratory measurement of pH and EC is well established, but the limitations and accuracy of in-situ pH and EC sensors with respect to soil moisture content is less understood. We tested three pH sensors and three EC sensors, ranging in cost from $32 to $655, in Tenosol and Ferrosol soils. Each sensor was calibrated using standard solutions, and measurements were taken daily as the soils dried from saturation to 30% field capacity. Soils were also destructively sampled every three days for laboratory analysis using multiple traditional laboratory methods. Preliminary results show a strong influence of soil moisture on the voltage response of both pH and EC sensors, particularly for the lower-cost models. These inexpensive sensors provided inconsistent results compared to the more accurate and stable readings from the higher-cost sensors. However, the performance of low-cost sensors improved at higher moisture levels, suggesting a potential trigger point for in-situ measurements. These findings are important for enhancing continuous soil monitoring in remote areas and understanding the practical limitations of in-situ pH and EC sensors.

ACKNOWLEDGEMENTS

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GT 14 - 310 - P

DATA MANAGEMENT IN A MEDITERRANEAN REGION'S SOIL INFORMATION SYSTEM

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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A Soil Information System (SIS) is an integrated information system designed to facilitate the storage, analysis, management and dissemination of soil data. Significant progress has been made over the past decade in terms of available technologies and standards. However, in many countries, particularly in the Near East and North Africa Mediterranean regions, soil data often remains in non-digital format, making it difficult to access. To assess and monitor soil health there is a need to improve the availability and accessibility of soil data. One of the objectives of the PRIMA-funded SOILS4MED project (SOIL health monitoring and information systems FOR sustainable soil management in the MEDiterranean region) addresses this need by designing and developing a federated network of country-based soil information systems. This network aims to improve the interoperability, management, governance, and utilization of soil data across the Mediterranean region by establishing a federated architecture of SISs, starting with the development of a harmonized data model aligned with the World Reference Base for Soil Resources (WRB 2022), alongside the implementation of core functionalities for the ingestion, integration, and management of both legacy and newly acquired soil data.

Soil data within the system are categorized into three structured data entities:

Soil Profile: A full conventional soil profile description, including site and soil surface features, profile's layers characteristics, and associated laboratory analyses compliant with conventional soil survey protocols.

Soil Sample: Soil monitoring data that includes specific site and soil surface descriptions, sample layer features, and soil laboratory analyses, following the monitoring protocol developed by SOILS4MED.

Soil Indicator: Derived data generated through analytical or statistical aggregation of attributes from Soil Profile and Soil Sample datasets.

The SIS leverages an Object-Relational Mapping (ORM) approach within a GeoNode-based framework an open-source geospatial content management platform that integrates WebGIS functionalities compliant with OGC (Open Geospatial Consortium) standards.

Through the SIS, users can perform the following activities:

Data ingestion: Upload and validate legacy soil datasets through structured XLSX spreadsheets and/or georeferenced raster (TIFF) files, with automated quality control via schema constraints and auxiliary validation tables.

Data management: Execute full CRUD (Create, Read, Update, Delete) capabilities for Soil Profiles, Soil Samples, and Soil Indicators, ensuring flexible and standardized data handling.

Data dissemination: Publish soil datasets in multiple GIS-compatible formats through the OGC-compliant SIS catalogue, with support for spatial, temporal, and attribute-based querying.

Access control: Implement user-specific data access governance using GeoNode's integrated permission system, applicable through both web interfaces and RESTful APIs



GT 14 - 332 - P

STEPS TOWARDS THE CONSTRUCTION OF THE SOIL DATABASE OF THE MEDITERRANEAN REGION

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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The importance of soil data has grown with the increased need for sustainable land management and for addressing soil degradation threats, leading to the development of global soil databases and mapping tools. There is increasing demand for standardized, accessible, and detailed soil information to feed a range of national and international applications related to digital soil mapping and soil monitoring.

Legacy soil data constitute a relatively underutilized source of soil information. They are available in formats corresponding to the time and place of collection, and they often differ in standards for soil profile descriptions, laboratory methods, classification systems, map scales, georeferencing systems, data density, and formats. Therefore, the potential of these data can be exploited only if proper harmonization processes are developed and implemented, to make them interoperable with current soil description and classification systems, and data management tools.

In the Mediterranean region (MR) and the Near East and North Africa (NENA) countries, steps toward this goal are being taken through the PRIMA-funded SOILS4MED project involving partners located in Italy, Lebanon, Spain, Tunisia, Greece, Egypt, Jordan, Turkey, and Morocco. This initiative focuses on monitoring soil health and developing information systems to promote sustainable soil management. The project aims to collect, digitize, harmonize, and make available in the frame of country-owned Soil Information System (SIS), all the available legacy data at partner countries.

Over 11,000 soil profiles and 120 maps have been collected, with contributions from research institutes like IAO, CREA, and IRD/ORSTOM. The maps were scanned, digitized, and their classification systems were translated according to the WRB 2022 standards. The process for legacy soil profile data involved: (i) a comprehensive review of the collected data, (ii) detailed analysis of their different data models (different survey methods and coding/archiving systems and different classification systems), (iii) data selection, (iv) digitalization and harmonization of all the data according to the adopted standard data model.

The latter was based on the WRB 4th Edition soil classification and survey guidelines. When the original survey methods differed from WRB 2022, conversion tables created by the team were used to translate classifications into the WRB 2022 system. In fact, legacy soil classification systems were widely varied, ranging from CPCS, Référentiel pédologique, USDA Soil Taxonomy of many different editions, FAO or old WRB systems.

This process of collecting, evaluating, integrating, and harmonizing legacy data using a single data model and classification system (WRB 2022) enabled the design and implementation of the first WRB 2022-compliant SIS-database, which will be shared with the international community as a result of the SOILS4MED Project.

GT 14 - 360 - P

INTEGRATING MINERAL-ASSOCIATED ORGANIC CARBON SATURATION WITH A PROCESS-BASED MODEL TO ASSESS THE SOIL ORGANIC CARBON SEQUESTRATION POTENTIAL IN AGRICULTURAL SOILS OF TAIWAN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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Soil organic carbon (SOC) sequestration is regarded as a key strategy for mitigating climate change, understanding its capacity and dynamics is essential for identifying suitable areas for implementing carbon sequestration farming practices. In this study, the saturation of mineral-associated soil organic carbon (MAOCsat) is used as an indicator to assess SOC sequestration capacity, while the rate of SOC change (ΔSOC) during 2021-2040, simulated by the RothC model serves as an indicator for evaluating SOC sequestration capability. The mean values of MAOC saturation and SOC change rate were used as the threshold to distinguish between high and low categories. Based on these two indicators, four SOC sequestration potential classes including R1 (high MAOCsat / low ΔSOC), R2 (low MAOCsat / low ΔSOC), R3 (high MAOCsat / high ΔSOC), and R4 (low MAOCsat / high ΔSOC) were derived for the spatial assessment of SOC sequestration potential. Results show that the proportions of R1, R2, R3, and R4 are 17%, 33%, 15%, and 35%, respectively, in agricultural soils of Taiwan. Among the classes, R1 exhibits the lowest sequestration potential, whereas R4 shows the lowest and has greater potential for SOC accrual. Among paddy fields, upland fields, and orchards, 45%, 50%, and 48% of their respective areas were classified as R4, whereas only 2%, 5%, and 9% were classified as R1. However, most low sequestration potential areas (R1) are concentrated in the central mountainous region and eastern Taiwan, where the SOC has reached a steady-state. The findings of this study offer comprehensive information to support policymakers in planning strategies to enhance SOC sequestration.

KEYWORDS

SOC sequestration potential, Mineral associated organic carbon saturation, RothC model, Digital soil assessment



GT 14 - 418 - P

INFLUENCE OF TERRAIN-INDUCED MOISTURE PATTERNS ON SOIL ORGANIC MATTER IN SEMI-ARID PASTURES OF NUROTA, UZBEKISTAN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Soil Organic Matter (SOM) plays a pivotal role in soil health and carbon sequestration in drylands. The Nurota region in Uzbekistan is a semi-arid, ecologically diverse landscape that comprises lowlands and highlands, historically impacted by sedentary grazing and crop cultivation. The land use and topographic mosaic of this landscape contributes to intricate spatial patterns of SOM distribution. This study assesses how and to what degree terrain-induced moisture patterns, summarized in a Topographic Wetness Index (TWI) allows to interpret the distribution of SOM using 200 samples collected across the landscape. While the TWI is useful to estimate soil moisture variability [1], its predictive strength is often limited by the landscape complexity [2]. In Nurota, moisture gradients indicated by the TWI reveal distinct differences between lowlands and highlands. However, the influence of land use, particularly grazing and cultivation appears to override the predictive power of TWI in explaining SOM variability. We used the TWI derived from D8 (TWI values –3 to ~18, ArcGIS Pro) and FD8 (TWI values 3 to ~29, QGIS + WhiteboxTools) flow algorithms to explore their respective relationships with SOM distribution [1]. These approaches differ in the inclusion (FD8) or exclusion (D8) of moisture-rich zones. The D8-based TWI yielded a weak negative correlation with SOM ($r = -0.28$; $p < 0.001$), while FD8 showed a weak but statistically significant inverse relationship ($r = -0.26$; $p < 0.001$). Our study illustrates how flow direction models can affect interpretations on the distribution patterns of SOM suggesting that hydrological accumulation in this area is not a primary driver of SOM variation, aligning with the results of a recent study [3] that investigated SOC variability in a semi-arid watershed using NDVI and TWI. SOM content across the Nurota landscape ranged between 1.2-5.9%, with a median of 2.5%, indicating low to moderate SOM levels. The spatial interpolation of SOM using ordinary kriging showed hotspots, though the extrapolation power beyond sampled zones remained limited. These findings confirm that in ecologically complex drylands, terrain-based indices like TWI have limited predictive power, and modeling of SOM requires multi-factorial approaches that integrate both biophysical and anthropogenic components.

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GT 14 - 487 - P

A REVIEW OF REGIONAL AND NATIONAL METEOROLOGICAL NETWORKS IN THE UNITED STATES OFFERING SOIL MOISTURE SENSORS AND A REVIEW OF THE ANALYTICAL METHODOLOGY

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soil moisture is a significant factor in Earth's hydrological cycles that influences weather, drought, climate, and water resources on land and in water bodies. However, throughout most of the 20th century, soil moisture received less attention and was not included in many hydrological studies. In the 1978, J. W. Deardorff with the United States' National Center for Atmospheric Research started to demonstrate the relationship between soil moisture and meteorologic conditions. Just two years later in 1980, G. C. Topp at the University of Toronto developed the Topp Equation - the first empirical calibration for soil moisture using time domain reflectometry (TDR). Additionally, that same year, M. T. van Genuchten published the van Genuchten Equation, which established a numerical relationship between soil moisture an unsaturated hydrologic head. Starting in the 1990s, the United States Department of Agriculture began using impedance-based soil moisture sensor technology to equip SNOTEL sites for water shed scale water supply forecasts. Since then, numerous large-scale regional meteorological networks incorporate soil moisture sensors, often referred to as 'mesonets', have emerged worldwide.

Soil water dynamics is complex often not well understood. Analytical methods using electromagnetic principles rely on the behavior and distribution electromagnetic energy in soil, making the operational theory of commercial sensors unclear at times. Soil moisture exhibits significant variabilities in space and time, as well as being influenced by hydrological and mineralogical properties of the soil. These factors give rise to several misconceptions about soil moisture monitoring.

This presentation discusses the growing importance of soil moisture as a critical parameter of the Earth's hydrological cycle. This discussion also focuses on the objective and goals of North American soil moisture monitoring networks. Furthermore, the availability and emerging electromagnetic sensor technologies are reviewed. Lastly, calibration and validation soil sensors are also examined.

Currently in the United States there are about 27 major regional meteorological networks that have soil moisture sensors. There are a total of 1880 stations with over 7300 soil moisture depths the between the 27 networks. 60 to 70 percent of the 7300 soil sensors are a coaxial impedance reflectometry technology called the HydraProbe manufactured by Stevens Water Monitoring Systems, Inc. based in Portland Oregon USA.

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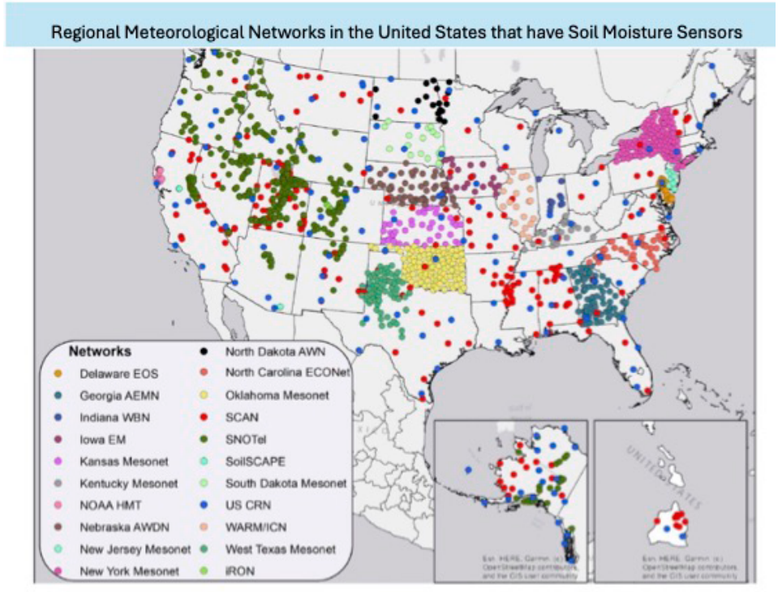
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GT 14 - 509 - P

MARMOT: MONITORING OF ALPINE GLACIAL LAKES USING INNOVATIVE ROBOTIC PLATFORMS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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The cryosphere plays a pivotal role in driving hydrological dynamics and soil-water interactions in high-mountain environments. However, mountain glaciers are rapidly retreating in response to rising atmospheric temperatures driven by climate change, leading to the formation and expansion of glacial lakes. These aquatic ecosystems act as sentinels of global change due of their vulnerability to climate-driven shifts, high sensitivity to external perturbations, and limited direct anthropogenic influence. As reservoirs of glacial meltwater, glacial lakes show water chemistry that reflects ongoing melt processes and the potential release of legacy contaminants stored in ice. Despite their remote location, these lakes are also particularly susceptible to long-range atmospheric transport of pollutants, which may increase their ecological vulnerability. Therefore, long-term monitoring of hydrochemical and biological dynamics in these lakes is essential to understand ecosystem responses to accelerating environmental change. However, their inaccessibility and the complex logistics of sampling result in scarce data and low temporal resolution, limiting the ability to capture seasonal and annual trends.

The MARMOT project addresses the need for sustainable, low-impact monitoring of sensitive high-mountain aquatic ecosystems by developing innovative robotic platforms with integrated environmental sensors. A lightweight Autonomous Surface Vehicle (ASV), equipped with advanced sensing technologies, is being developed. Designed for portability, the ASV can be carried in a backpack to remote mountain lakes, where it will conduct automated water sampling and perform in-situ measurements of key water quality parameters.

For the development and testing of the ASV, climatic and geomorphological constraints, physicochemical characteristics of two glacial lakes in the Italian Alps (proglacial lakes of the Indren and Fellaria glaciers), were considered. Water chemistry data—including concentrations of anions and cations, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), nitro-PAHs (N-PAHs), endocrine disruptors, and potentially toxic metals originating from both natural and anthropogenic sources—collected via traditional sampling methods will be compared with those obtained through the automated sampling system, and when feasible, used for sensor calibration. Ancillary data will support the identification of environmental variables affecting ASV performance and help establish baseline concentrations of PAHs, PCBs, and endocrine-disrupting compounds in these remote environments. The use of automated sampling will allow the detection of horizontal and vertical chemical gradients, enable high time-resolution datasets, and support the analysis of temporal trends of selected analytes in lake water in relation to atmospheric deposition and surrounding soils, aiding in the identification of pollutant sources.



GT 14 - 563 - P

SATELLITE-DERIVED SOIL INFORMATION FOR ENCOURAGING SUSTAINABLE LAND MANAGEMENT IN GERMANY

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The use of modern satellite technologies and analysis methods can provide large-scale soil information, complementing traditional in situ approaches. Regional changes in soil properties and ecosystem services – due to unsustainable land use or climate change – can thus be detected earlier, allowing timely countermeasures. The European Earth Observation Programme Copernicus offers freely available, high quality multispectral and radar satellite data essential for soil science stakeholders. Between 2010 and 2025, over 30 German-involved remote sensing projects generated satellite-based soil information. Common parameters include soil moisture, organic carbon content, soil sealing, land surface temperature, bare soil frequency, clay and iron oxide content, urban cooling performance, and soil infiltration potential. The Federal Institute for Geosciences and Natural Resources (BGR) encouraged satellite data use through the pioneering 'Copernicus Soil Network Office' project, fostering interdisciplinary collaboration, and thereby contributed to soil monitoring, sustainable land use, soil and water protection, and climate adaptation goals in Germany. Two recent workshops supplemented by an online survey identified key remote sensing soil applications in Germany: In monitoring, satellite data support the mapping of soil properties, peat soil, erosion, formation and distribution of soils, trafficability, drainage, contamination, and vertical land movement. In land use and spatial planning, applications include land use analysis, urban planning, land cover mapping, soil sealing determination/quantification, and mapping of regional soil characteristics by supporting regionalization approaches. In agriculture and production, Earth observation contributes to optimizing seeding rates, yield forecasts, drought stress monitoring, irrigation needs, carbon farming, land use statistics, and field boundary delineation for modelling. For decision-making and policy, remote sensing informs modelling, reporting obligations, soil mapping, and the comparability of measures. These findings highlight the growing importance of satellite-based Earth observation as a complement to conventional soil monitoring, with transformative potential for sustainable soil management and cross-sector decision-making. However, workshop participants and survey respondents identified still key challenges in using EO soil products, including fragmented data access, absence of centralized product catalogues, limited usability due to focus on bare soils, insufficient spatial resolution, lack of soil depth information, missing quality standards, and a shortage of user-specific training opportunities. Addressing these challenges through enhanced data integration, methodological standardization, and target group-specific capacity building will be crucial fully unlocking the potential of Earth observation for effective and sustainable soil management.

GT 14 - 579 - P

A PUBLIC ACCESS DIGITAL PLATFORM FOR ACCESSING THE SOIL VARIABLE VALUES REQUIRED TO INITIALIZE 3-PG PROCESS-BASED MODEL FOR DIFFERENT LOCATIONS IN PORTUGAL

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 16. CONNECTING PEOPLE AND SOILS

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In the context of climate uncertainty, forest modeling plays a fundamental role in forest management by enabling the simulation of various scenarios based on different management objectives. When modeling tree and forest stand growth, researchers have used empirical, hybrid, or process-based models (Burkhart and Tomé, 2012). Empirical models are developed combining statistical techniques with long time series of data gathered across a range of locations. Consequently, this type of models have limited applicability to predict growth under different climate and management conditions different from those reflected by the data used for their development. This has led to growing interest in physiologically based forest growth models. One of the simplest and most versatile models is 3-PG (Physiological Principles in Prediction Growth). This physiologically based model has been widely used and tested to predict the primary productivity of forests worldwide. In terms of soil information, the 3-PG model uses three variables: the maximum available soil water (MaxASW), soil fertility, and soil texture class (Landsberg and Waring, 1997). Soil fertility is assigned through a fertility index FR (fertility rating), which varies between 0 and 1 and in addition to affecting net primary production (NPP) defines allocation to roots. Meanwhile, the textural class affects the soil-water-dependent growth modifier (Landsberg and Sands, 2011). The maximum available soil water interacts with the evapotranspiration module.

The objective of this work was to create a database containing the MaxASW, FR, and soil textural class values for continental Portugal. The first step consisted of combining the National Forest Inventory (NFI) photopoint grid with soil cartographic information from SNISolo and EPIC WebGIS Portugal using a Global Information System. In the second step, the pedological unit at each NFI photopoint in the grid was identified and the MaxASW and FR values, as well as soil texture class, were estimated based on soil cartography descriptive memos that were combined with analytical data from different soil profiles when available. This allowed assigning one or more values of each variable to each photopoint, depending on the characteristics of the corresponding pedological unit. The compilation of this information at national level will enable to apply the 3-PG across the country allowing users to perform simulations selecting the values for their location, considering the soil type in the pedological unit that best corresponds to their situation.

This information will be made publicly available in a digital platform. An alternative option, when the user opens a soil profile, is to enable users to enter their soil-related information and receive the values of the three aforementioned variables in return.

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The following table illustrates the output for the specified point.

		FR	MaxASW (mm)	Textural Classe
X Coordinate	**SDOM1**			
225750	RG.lep.dy	0.1	32	TL
Y Coordinate	**SDOM2**			
315750	CM.len.dy	0.2	58	TL
	Oher Soils			
	CM dy.cr	0.2	101	L
	LP.dy	0.1	21	TL
	RG.len.sk	0.3	56	TL
	CM.lep.sk	0.1	60	SL

L – Loam; SL - Sandy Loam; TL- Silty Loam (USDA System).



GT 14 - 596 - P

SYNERGY OF MULTIVARIATE GEOSTATISTICS AND XRF MEASUREMENTS IN URBAN SOIL CONTAMINATION SOURCE APPORTIONMENT: A CASE STUDY FROM DEBRECEN

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 13. LAND FRAGMENTATION, URBAN AND ANTHROPOGENIC SOILS

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This study assessed the spatial distribution, concentration levels, and potential sources of eight heavy metals (As, Cd, Co, Cr, Cu, Ni, Pb, Zn) in urban surface soils across Debrecen, Hungary's second largest city. During the summer and autumn of 2022, 295 topsoil samples were collected, providing comprehensive spatial coverage of the city's urban fabric. Metal concentrations were determined using Skyray Instrument Explorer 9000 X-Ray Fluorescence spectrometer, and results were interpreted through descriptive statistics, correlation analysis, hierarchical clustering, principal component analysis (PCA), and ordinary kriging interpolation. The analysis revealed a dual origin of metals: As, Co, Pb, and Zn showed strong anthropogenic signatures, particularly linked to traffic, urban waste, and construction materials, while Cr and Ni were associated with natural geogenic sources. Cadmium presented mixed behavior, reflecting both lithogenic and point-source urban pollution. Unlike earlier studies, the evaluation incorporated Hungarian and Dutch regulatory benchmarks to identify exceedances of environmental quality thresholds. PCA was statistically validated (KMO = 0.618, Bartlett's $p < 0.001$), confirming the robustness of the grouping. Mapping highlighted contamination hotspots around traffic corridors and newly industrialized zones, including areas influenced by recent economic expansions of automotive and battery manufacturing. The findings underline the importance of high-resolution soil monitoring in rapidly urbanizing environments and offer a current benchmark for future risk assessment and urban planning in Hungary and comparable Central European contexts.

ACKNOWLEDGEMENTS

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GT 14 - 645 - P

SOIL–LANDSCAPE RELATIONSHIPS FOR A SOIL MAPPING APPROACH IN THE PROVINCE OF HUELVA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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The characterization and mapping of forest soils cannot currently be carried out using remote sensing data, which is why the territorial extrapolation of soil sample information must be done through landscape interpretation. This study presents the statistical tools and soil–landscape relationships identified to map the forest soils of the province of Huelva, a Mediterranean climate area with highly diverse lithologies, mostly siliceous.

The main target variables of this mapping were the WRB-FAO-2006 taxonomy (IUSS Working Group WRB, 2007), depth (PRF), water retention capacity (CRA), and erodibility (FK), all of which are of great interest for forest management and other applications.

To establish relationships between environmental (independent) and soil (dependent) variables, easily obtainable relief variables from digital terrain models, climatic variables, and lithofacies (as the base variable) were selected for a provincial-scale analysis. To eliminate lithological influence and promote the effect of other variables, both environmental and soil variables were normalized according to the average values each variable reaches in soils of the same lithofacies. Normalized, raw, and categorized variables were used. Lithofacies were grouped by similarity into 27 simplified lithofacies (LtS), which can be subdivided into litho-edaphic groups (GL).

Statistical analysis included non-parametric techniques, correlation analysis, multivariate linear regression models, and mean comparison through ANOVA. The first three techniques were useful for identifying the most influential variables. Mean comparison allowed for the establishment of significant differences between average soil values, making territorial extrapolation more reliable. For variance analysis, categorized versions of environmental variables were used to identify significant differences in PRF or CRA among the different categories.

Lithofacies of coherent sedimentary rocks showed significant influence from climate types and general relief, as well as slope variables. For lithofacies with little variation in climate and relief—such as plutonic rocks and Plio-Quaternary materials—this influence could not be evaluated (see table).

The product of these coefficients was used to estimate soil properties when a sufficiently significant number of samples was not available.

Local landforms also had a significant influence on the variation of soil properties, particularly in the case of microtopography regarding soil depth:

Microtopography Type Mean Difference (%) No. of Cases

1 - Convex 0.845 -15.5% 28

2 - Flat-convex 0.962 -3.8% 41

3 - Flat 1.005 0.5% 90

4 - Flat-concave 1.046 4.6% 55

5 - Concave 1.118 11.8% 25

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VARIABLE	Category	No. of Cases	PRF	CRA
Precipitation	High	19	1.094	1.052
	Low	129	0.934	0.920
	Medium	92	1.073	1.102
Relief	Rugged	95	1.023	0.965
	Gentle	145	0.985	1.023
Temperature	Cool	30	1.032	1.008
	Intermediate	119	1.003	1.028
	Warm	91	0.986	0.961

The correction coefficients for climate and relief categories



GT 14 - 731 - P

CREATION OF A HUNGARIAN NATIONAL SOIL HYDROLOGIC GROUPS MAP THROUGH THE USE OF K-MEANS CLUSTERING AND EXPERT-BASED RULES

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 08. SOIL-PLANT-WATER INTERACTIONS

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Our understanding of soil water retention and hydraulic conductivity – both of which are essential for environmental assessments and applications – can be largely improved by regional and national 3D soil hydraulic maps. Large-scale models, while benefitting from these data, are computationally demanding, often making their aggregation a necessity.

In this study, we created the soil hydrologic groups map of Hungary by conducting k-means clustering and implementing additional expert-based rules afterwards. The clustering was applied to eight hydraulic parameters across six depths of the 100 m resolution 3D HU-SoilHydroGrids database. Following the initial clustering, an additional expert-based refinement of the data was carried out using soil profile depth, genetic type, electrical conductivity, and exchangeable sodium content, in order to account for the underrepresented soil types with distinct water management characteristics.

We delineated 68 different soil hydrologic groups as a result, each defined by distinct hydraulic properties, such as van Genuchten parameters (describing water retention), as well as saturated hydraulic conductivity. Our map supports country-scale hydrological modelling with high computational demand, but is also potentially useful for environmental management and agricultural planning, since it ensures the consistent treatment of similar soils in analysis and decision-making throughout Hungary.

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GT 14 - 733 - P

SUPPORTING THE IMPLEMENTATION OF SOIL MONITORING LAW IN HUNGARY BY THE REGIONALIZATION OF SOIL DEGRADATION

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The introduction of the Directive on Soil Monitoring and Resilience proposed by the European Parliament and Council is supposed to be preceded by specific preparatory works at Member State level, such as the definition of so-called soil districts (also referred as soil health zones) together with the development of a soil monitoring system based on the elaborated zonalization. Three subsequent terms of Presidency of the Council of the European Union (the Belgian, Hungarian, and recently the Polish; it is held in rotation) aimed to finalize the concept elaboration and to legislate the Directive, until very recently without success (a trilogue agreement was reached on the 10th of April). While final delineation of soil districts could not have been elaborated, certain tests were carried out to establish a proper zonalization. In the present paper soil health is approached from soil degradation point of view and soil districts from the regionalization of soil degradation respectively, which latter has already been addressed from time to time in the last decades.

In the frame of Land Degradation Mapping Sub-project of PHARE MERA '92 -, identification, delineation and description of Hungary's major land degradation regions at were accomplished by building and analyzing a digital land degradation geographic database in the late '90s. The applied GIS analysis techniques were mainly based on traditional cartographic methods and had not exploited the opportunities, which were later emerged in DSM. The former initiative of the Commission of the European Communities by the Thematic Strategy for Soil Protection proposed a comprehensive approach to soil protection with ample freedom on how to implement its requirements on the identification of threats and specific risk areas left to Member States. In 2007, the techniques available at that time provided by DSM together with the renewed interest in spatial delineation of areas endangered by various soil threats were combined for the recompilation of land degradation regions of Hungary. Different levels of specific threats were determined in the form of categories. For the overall characterization of degradation regions, indices were introduced serving as spatial land degradation indicators.

In the last decade the Hungarian Soil Spatial Data Infrastructure has been renewed, GSM conform digital soil maps on primary together with certain secondary, derived soil properties were elaborated in the frame of DOSoReMI. The work has been continued with the modelling of certain soil functions and (degradation) processes. For the support of Soil District designation all, nationally relevant soil degradation processes have been digitally (re)mapped using specific DSM approaches. The newly (re)complied soil degradation maps have then been submitted to spatial classification procedures to regionalize the processes. The results of the various classification scenarios have been used to produce alternatives for soil districts.



GT 14 - 793 - P

PROXIMAL SOIL SENSING THROUGH AI-DRIVEN EDGE-CLOUD WORKFLOWS IN AGRICULTURE FIELDS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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In the face of global soil degradation and increasing demands for sustainable land management, advancing in-situ soil monitoring is critical. This abstract presents the outcomes of the EMPYREAN Horizon Europe project, specifically focusing on the use case “Proximal Sensing in Agricultural Fields”. This use case leverages edge computing, AI-based data analytics, and robust IoT infrastructure to enable high-resolution, real-time soil data acquisition and decision-making support.

The architecture integrates soil spectrometry systems, deployed on mobile platforms, with edge-enabled devices that handle initial data preprocessing and inference using locally trained AI models. These models are optimized to extract soil organic carbon (SOC) indicators from hyperspectral and Vis-NIR reflectance data. Workflows developed within the EMPYREAN platform, enable dynamic orchestration across devices, edge nodes, and cloud backends. This architecture ensures efficient handling of large datasets, continuous system adaptation, and seamless communication within heterogeneous and sometimes intermittently connected environments.

Central to this approach is the novel use of AI-driven orchestration mechanisms for adaptive workload placement, vertical autoscaling of containerized inference tasks, and integration with EMPYREAN’s distributed Decision and Telemetry Engines. These capabilities allow for intelligent routing of soil sensing tasks to optimal nodes based on network conditions, computational load, and energy efficiency considerations.

Preliminary integration of the system components has demonstrated the feasibility and robustness of the proposed architecture under realistic agricultural conditions. Initial deployments show promising performance in handling heterogeneous sensor inputs, executing AI inference pipelines efficiently at the edge, and dynamically orchestrating workloads across resource-constrained environments. The system exhibits a high degree of modularity and adaptability, supporting low-latency data processing and scalable model deployment across varying field configurations. These developments pave the way for comprehensive evaluation in diverse agricultural scenarios, aiming to validate system performance in real-time SOC monitoring, data-driven decision support, and resource optimization.

This contribution reflects a step forward in embedding digital innovation into soil science and monitoring. By integrating AI, edge-cloud orchestration, and proximal sensing technologies, EMPYREAN’s approach addresses key soil preservation challenges and supports the broader EUROSOIL mission to foster actionable, technology-driven strategies for sustainable soil stewardship.

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GT 14 - 821 - P

SATELLITE-BASED INTRA-ANNUAL SOIL TEMPERATURE ESTIMATION, MAPPING AND REGIONALIZATION

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 02. SOIL PHYSICAL CHEMISTRY

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Earth’s surface is a critical climate system component for energy exchange [1,2]. Soil temperature controls soil processes [3,6], influences nutrient cycling and greenhouse gas fluxes [12]. Traditional models rely on point observations [5,18], limiting spatial coverage. Satellite-based methods offer potential for mapping soil temperature dynamics where in situ data are scarce [8, 22].

This study uses estimates from a satellite-based method that integrates Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI) and solar declination (Ds) with station records to characterize spatiotemporal variation of soil temperature at 5 and 10 cm depth in Uruguay. Validated models achieved R^2 = 0.84 for SMTc5 cm and R^2 = 0.87–0.89 for SMTc10 cm, with RMSE = 2.3 K for SMTc5 cm and RMSE = 1.8–2.1 K for SMTc10 cm.

Based on monthly mean soil temperature maps (2001–2021) derived from validated models, we conducted a country-scale regionalization of intra-annual soil temperature variability via principal component analysis and K-means clustering. Monthly 1 km rasters were generated; missing values filtered. Principal component analysis reduced the twelve-layer dataset to two modes explaining > 90 % of variance. K-means clustering (k = 4) on component scores delineated four thermal regions. Resulting maps reveal distinct gradients in annual mean and amplitude.

Soil temperature variability aids environmental regionalization and production planning [3,31]. Thermal-regime data inform sowing date and weed management [4] and pest distribution [35]. Heat and water balances are coupled [6]; temperature affects soil hydraulic properties [5,13], while water content controls thermal conductivity and latent-heat flux [5]. Multi-depth temperature data enable estimation of heat capacity and diffusivity, serving as moisture proxies [5].

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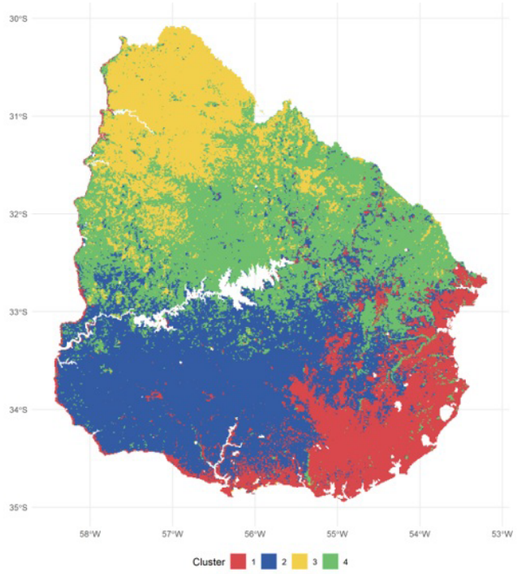
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K-means Clustering of Intra-Annual SMTc5 cm Variability in Uruguay



GT 14 - 851 - P

SOIL MAPPING IN MOUNTAIN ENVIRONMENTS: HOW MANY PROFILES? ONE EXAMPLE FROM THE APENNINES

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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It is known how soil is among the most important compartments of the biosphere and the pillar of terrestrial ecosystems: it plays a pivotal role in the cycling of nutrients, in water regulation, carbon storage, and is the basis for food production. Given its influence on the health of ecosystems and on human activities, it is fundamental to study and monitor this non-renewable resource and to promote its correct management. To achieve a thorough knowledge of soil, one cannot oversee its complexity: from the microscopic scale, to genetic horizons, to soil-landscape associations, soil is a complex system at every scale. This complexity originates in the factors which direct soil genesis and evolution: climate, organisms, parent material, relief, time, and the interaction between them, produce an intricate and diverse arrangement of soil types and properties. Soil maps are used to convey this complexity and make it into useful information for land managers and policy-makers. From conventional polygon-based soil maps to the more recent techniques of digital soil mapping, soil surveys remain the first and most important step of the mapping process. Planning a soil survey is no easy task that requires a thorough knowledge of the soil-landscape relationships. But when the survey area happens to be mountainous, not only the soil-landscape relationships are often more complex, new constraints need to be accounted for: accessibility, remoteness, and hotspots of soil diversity. These characteristics, typical but not limited to mountain areas, make it even more difficult to answer to the question: How many profiles? This study proceeds from the experience of the creation of the soil map of the Frignano-Corno alle Scale Regional Parks in the mountains of Northern Italy, where legacy data was completed with a new soil survey based on a stratified sampling design and expert knowledge: “landscape units” were created according to some soil forming factors, and the location of the profiles within each unit was chosen following an accessibility analysis and expert knowledge, with the intention to capture as many soil types as possible. For this study, we took into account the landscape units which occupy most of the elevation range between 1200-1900 m asl: beech forests (A), grasslands and heathlands (B), ponds and peatlands (C), overlying turbiditic sandstones. The extension of each unit was very different: unit A was 5635 ha, unit B was 2763 ha, and unit C was only 23 ha. Despite this, more diversity was found in the soils of unit C both in terms of Soil Taxonomy great groups and as a higher standard deviation in some fundamental soil properties such as organic carbon, C:P and N:P ratios. This not only highlights how ponds are hotspots of soil diversity, but also suggests that surface area isn’t always the most appropriate metric when it comes to decide the amount of soil profiles needed, and that expert knowledge remains a fundamental resource in soil mapping.

GT 14 - 857 - P

INTEGRATING HIGH-RESOLUTION SOIL AND MICROCLIMATE MAPPING FOR AGRONOMIC FIELDS: A GIS-BASED METHODOLOGY IN A TRUFFLE FIELD (RÁCALMÁS, HUNGARY)

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Understanding the spatial heterogeneity of soils and near-surface microclimate is essential for the sustainable management of high-value crops such as truffles. This study presents a methodology that integrates soil mapping with digital surface model (DSM)-based microclimate modelling to identify and delineate favourable and unfavourable zones for truffle cultivation. The approach is based on high-resolution digital soil mapping supported by field soil profile surveys, laboratory analyses, and spatial extrapolation of point data using representativity-driven zonation (Dobos et al., 2010). Prior to fieldwork, a spatial database was compiled using geomorphometric and geological data, hydrological indices, and microtopographic forms derived from UAV based DSM.

Microclimate modelling was conducted with pre-validated models in SAGA GIS, using digital surface model. The suite of models includes Cold Air Flow and Velocity (detect possible cold-air-pool (Dorninger et al., 2011) areas;), Wind Exposition Index, Wind Shelter Index (for multiple prevailing wind directions, Winstral et al., 2002), Diurnal Anisotropic Heat Index (Böhner & Antonic, 2009), Topographic Wetness Index (Beven & Kirkby, 1979), Potential Evapotranspiration (Turc, 1961) and solar radiation and sunlight duration models (Hofierka & Šúri, 2002). The ShadeMap tool was used to model solar exposure under realistic vegetation shading, providing high temporal and spatial accuracy.

The integrated GIS analysis of soil and microclimate maps enables the identification of management zones that differ in their suitability for truffle cultivation. This methodological framework has been successfully tested on a previous site and is now reproduced in a truffle field located in Rácalmás, Hungary. The approach supports spatially explicit, precision-oriented agroecological planning and may contribute to sustainable truffle production by reducing risk associated with frost exposure, soil moisture variability, deflation and erosion potential. Thus, the GIS-based soil and microclimate mapping can support precision truffle zoning.

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GT 14 - 896 - P

MACHINE LEARNING-BASED APPROACH FOR WHEAT YIELD PREDICTION IN MOROCCO USING SOIL AND CLIMATE DATA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Precision agriculture offers promising solutions to the pressing challenges of food security and climate resilience, particularly in semi-arid regions (Getahun et al., 2024; Petrovic and Csambalik, 2025). In this study, we develop a modular Machine Learning pipeline (MLP) to forecast wheat yield by integrating soil physicochemical properties, fertilization data, and climate variables within Moroccan agricultural systems. The research specifically aims to assess how the spatial and temporal heterogeneity of environmental conditions influences wheat yield prediction across both irrigated and non-irrigated zones in the study regions. Model inputs include soil texture (sand, silt, clay), pH (water and KCl), organic matter, CEC, macro- and micronutrients (e.g., P_2O_5, K_2O, MgO, CaO, Zn, B), as well as crop-specific fertilizer applications. Climatic data consist of average temperature retrieved from remote sensing sources (Copernicus CERRA reanalysis) and cumulative precipitation recorded by in-situ weather stations. Before modeling, the dataset underwent preprocessing, including data cleaning and normalization. Multiple machine learning algorithms were tested, among which LightGBM demonstrated the best predictive performance. The final model achieved a cross-validated R^2 of 0.90 and a Mean Absolute Error (MAE) of 3.3 Qx/ha, confirming its strong performance across varying agro-environmental conditions. This work contributes to the development of scalable, data-driven decision-support tools tailored to the Moroccan agricultural context. It offers valuable insights for optimizing fertilizer use, guiding crop selection, and enhancing resilience to climate variability in semi-arid environments.

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GT 14 - 948 - P

DEVELOPMENT OF HIGH SPATIAL RESOLUTION DIGITAL SOIL TEXTURE MAPS BASED ON LEGACY SOIL DATA FOR THE LAKE BALATON CATCHMENT

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Since the 1970s, a large amount of soil survey data is available for two thirds of Hungary’s agricultural land, with a very high spatial detail and from various sources. The vectorisation of the soil data has resulted in the generation of the Profil-level Database of Hungarian Large-Scale Soil Mapping (Hungarian acronym: NATASA), which currently contains data on 148,000 soil layers for about 37,000 soil profiles. The soil database not only provides information at a very high spatial resolution for topsoil, but also ensures a good representation of deeper soil layers.

In our current work, we used the NATASA data to produce soil texture maps according to USDA classification for the Balaton catchment area with a spatial resolution of 25×25 m using pedotransfer functions to estimate the sand, silt and clay content of the soils. The soil profile data (field descriptions and results of laboratory investigations) were revised according to the Hungarian genetic soil classification system and expert based criteria (by developing a filtering system according to soil subtypes),. Soil texture maps were created for standard GlobalSoilMap (GSM) soil depths (0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm) based on a SCORPAN model using environmental auxiliary variables (topography, geology, groundwater, mean temperature and precipitation, surface cover). Map estimations were performed using random forest kriging in “R” environment. A 5-step cross-validation was performed on the predictions, where the mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) were calculated from the results.

The soil texture maps presented in our study, together with soil maps of other basic properties (organic matter content, pH and lime content), could form the basis for future target maps (e.g. hydrophysical property maps), which could provide valuable information on the extent of vulnerability of Hungarian agricultural areas to inland water and drought sensitivity to climate change induced weather extremes. This could help in the development of a regional drought and water deficit management system, to underpin irrigation investments and to further develop the methodology of the current inland water vulnerability map.

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GT 14 - 982 - P

EVALUATING THE POTENTIAL OF SENTINEL-2 DATA TO ASSESS THE COARSE FRAGMENT COVER OF THE SOIL SURFACE WITHIN A SPANISH VINEYARD.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 09. SOIL HEALTH

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The presence of coarse fragments (CF) on the soil surface is a critical factor influencing the assessment of key soil properties such as hydraulic conductivity and C stocks, as well as erosion processes [1–3]. This study investigates the potential of Sentinel-2 (S2) data to estimate soil surface CF cover for an 82-ha trellis-trained vineyard (Burgos, Spain), with ~3 m-inter-row spacing. CF cover (%) was estimated using the point-count method via SamplePoint [4], based on nadir photos taken ~1 m height above ground level, at 60 points repeatedly during three field campaigns. Based on two S2 time series (Jan 2023–Feb 2024 and Jan–Apr 2023 (vine dormancy)), six spectral indices computed within a 30 m-buffer were clustered through hierarchical agglomerative clustering (HAC) and principal component analysis (PCA), which led to the selection of the Non-photosynthetic vegetation soil separation index (NSSI). Assessment of NSSI relevance relied on correlating NSSI values, extracted from S2 images closest to field campaign dates, with the average CF cover, with and without applying an NDVI threshold of 0.4. A Random Forest algorithm was then used to predict CF cover, with 70% calibration 30% validation split repeated over three random iterations. Two approaches were tested, with and without NDVI threshold: (1) S2 bands only, and (2) S2 bands + NSSI + NDVI.

NSSI was moderately correlated with CF cover (R^2 = 0.47–0.60), while best correlated with NDVI threshold (R^2 = 0.48–0.77). Calibration performance was good across all models (R^2>0.6; RMSE<16.75%; RPD>1.62; RPIQ>2.23), even though validation results were variable. NDVI thresholding alone did not improve validation, but adding NSSI+NDVI as predictors enhanced validation accuracy. The best performance was obtained by combining data from all campaigns using S2 bands + NSSI + NDVI without any NDVI threshold (R^2 = 0.42; RMSE = 17.53%; RPD = 1.55; RPIQ = 2.05).

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GT 14 - 1018 - P

LEACHED SOIL WATER: AN UNTAPPED SOURCE OF INFORMATION ON SOIL BIODIVERSITY?

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 04. SOIL BIOLOGY

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In recent years, the study of soil biodiversity has increasingly relied on the direct extraction of DNA from soil samples, followed by the identification of organisms through the sequencing of specific genomic regions. While estimating microbial α-diversity from a small number of pooled soil cores is typically sufficient, assessing the biodiversity of soil meso- and macrofauna using metagenomic approaches usually requires more intensive sampling due to the lower population densities and greater mobility of these organisms (Oliverio et al., 2018, Li et al., 2021)..

Environmental DNA (eDNA), which encompasses whole cells, extracellular DNA, and occasionally entire organisms, is being increasingly used to detect the presence of species in soil and water environments where direct observation is challenging (Thomsen and Willerslev, 2015). In soil systems, water migrates both vertically and horizontally, transporting microorganisms and DNA fragments (Pote et al., 2005, Gulden et al. 2005, Griebler and Lueders, 2009, Villacorta-Rath et al., 2023, Varzandi et al., 2024). Collecting eDNA from soil water using lysimetric methods offers a minimally invasive option for long-term biodiversity monitoring (Farsad et al., 2019). However, the effectiveness of this approach in recovering sufficient, high-quality eDNA for reliable taxonomic identification has not been extensively evaluated.

In this study, we evaluated the efficiency of two commercial (Qiagen, NucleoSpin) and two custom-developed DNA extraction kits (Centrikon, Promega) for recovering eDNA from rainwater and leachate samples. We compared DNA concentrations obtained from amplified regions using three primer pairs: 1391f/eukBr, 341F/805r, and BF3/BR2. Additionally, we assessed the proportion of non-target COI amplicons relative to target Metazoan OTUs. We estimated α-diversity, β-diversity, and the relative abundance of the most dominant Arthropoda taxa across three sample types collected along the soil vertical gradient: rainwater, leached soil water, and underground water.

Our results did not reveal statistically significant differences in DNA concentrations among the extraction kits and sample types ($p > 0.05$). Similarly, no significant differences in α-diversity indices were observed, although species composition suggested some notable variation among sample types. Pairwise comparisons showed that underground water and rainwater samples differed significantly ($p = 0.001$), while other comparisons were either marginally significant or not significant, possibly due to small sample sizes. Given the unbalanced sampling design, we tested for homogeneity of dispersions and confirmed that the observed differences were not driven by within-group variability.

Estimating soil biodiversity from leached soil water collected via the lysimetric method proved challenging within the context of our current soil monitoring design. Further work is needed to address the faults and methodological issues identified in this study, namely: difficulty in obtaining sufficient amount of water sample, prevention of sample contamination, recovery of adsorbed eDNA and smaller free fragments of free eDNA, setting the PCR to fewer cycles to evade suppression of rare templates, make technical repetitions of each sample.

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GT 14 - 1023 - P

SPECTRAL CHARACTERIZATION OF GROUNDWATER INFLUENCED HYDROMORPHIC SOILS USING VISIBLE AND NEAR-INFRARED SPECTROSCOPY

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Prolonged water saturation, along with seasonal alternation between wet and dry periods, significantly influences the chemical and morphological properties of soils. Fluctuations in the degree of water saturation affect soil oxygen availability, which in turn impacts the oxidation states of key elements. The redox status of iron and manganese strongly determines their solubility and color expression. As evidence of reductive conditions, soils affected by excess moisture often exhibit characteristic hydromorphic features, such as mottling in yellowish-reddish and gray hues.

In addition to conventional laboratory techniques, a range of proxy sensing methods are now available for detecting these features, including the application of visible and near-infrared (VIS-NIR) spectroscopy. In the visible and near-infrared spectral range, soil constituents exhibit characteristic spectral fingerprints that enable both qualitative and quantitative assessment. These spectral signatures provide direct information on the main soil components, and indirectly reflect other physical and chemical properties that are influenced by these constituents. Since hydromorphic soils are strongly influenced by redox processes, their profiles are characterized by various forms of iron and manganese accumulations, which can be detected within the visible and near-infrared spectral range. Periodic water saturation affects the accumulation of soil organic matter as well, resulting in a characteristic composition of the organic components of hydromorhpic soils.

The present study aimed to identify specific ranges within the visible and near-infrared spectra of soils that are indicative of hydromorphic features. During the study, spectra from 30 hydromorphic soil profiles across Hungary were collected and analyzed. The soils were selected based on morphological indicators associated with iron and manganese accumulation, as well as evidence of groundwater influence within the soil profiles. Following the morphological description of the soil profiles, spectral data were collected systematically by horizon and analyzed using standard laboratory methods to establish a reference database for the calibration and validation of spectral measurements. The expected outcome of this research is the contribution of the analyzed soil samples to the development of a comprehensive national soil spectral library and the interpretation of fingerprints of hydromorphic features in the spectra. The poster will visualize the main diagnostic redox features and discuss their spectral signatures.



GT 14 - 1027 - P

NATIONAL-SCALE PREDICTIVE MAPPING OF PEAT SOILS IN AGRICULTURAL LANDS IN LATVIA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Reliable information on the extent of peat soils is crucial for effective policy and management aimed at meeting the EU's environmental and climate goals. In Latvia, soil data is largely outdated, based on field inventories at scale 1:10000 conducted over 35 years ago. Additionally, the national criteria for peat soil identification (peat depth > 30 cm) differ from the internationally accepted Histosols criteria (H > 40 cm); therefore, European-level data harmonisation is challenging.

To update and clarify the spatial distribution of peat soil in Latvia, we developed an ML-based predictive model that utilises remote sensing (RS) data to identify complex spatial patterns in agricultural landscapes.

Our study covers 2.336 million hectares of declared and abandoned non-forested agricultural land, with fieldwork conducted in 2021 and 2022, resulting in 21,185 georeferenced soil data points for model development.

Analysis of soil and RS data revealed that the most significant covariates for peat soil identification are Sentinel-2 sensors' B3, B4, and B8 band data and spectral indices, namely EVI, NDWI, and kNDWI, with increasing importance of terrain variables (e.g. depth-to-water, slope and its variability, topographic wetness index, depth-in-sinks) in abandoned farmlands. The relative importance of SAR (Sentinel-1) indices was relatively low.

Randomly selected 80% of the input data were used for model training, while the remaining 20% were used for validation. The XGBoost ML method (generalised boosted tree for binary logistic outcome with class-specific weighting for imbalanced input) was used to develop algorithms for six different subareas, categorised into three main groups: arable land, grasslands, and areas under tree or shrub vegetation. A subcategory with shadows around the edges was selected for every category. Predictions were computed at a spatial resolution of 10 x 10 m per pixel. In the final phase, minor variations between six model projections were smoothed by applying a moving window filter (3×3 focal cells) to impute the arithmetic mean value, thus conforming the results to national mapping guidelines, which specify a minimum soil mapping unit of 0.3 ha.

The mean accuracy for the ensemble was 90.2% (>85% in every model). Balanced accuracy is lower - 84.5% (>80% in every model), but the area-weighted mean reaches 86.3%. Independent test results show that models' precision and recall are relatively similar (ranging 60 – 80% between classes), with specificity scores (~90%) higher than sensitivity scores (~75%).

Overall, the model offers significant soil information and insight into peat soil modelling in the boreo-nemoral region and can be used to support decisions or in future soil survey events. Additional soil data acquisition and the implementation of environmental covariates (e.g., gamma radiometry data) must be considered in future to improve model quality and the identification of Histosols distribution.

ACKNOWLEDGEMENTS

This work was supported by the Norway Grants Climate and Environment Program 2014 – 2021 "Climate change mitigation, adaptation to them and the environment" pre-defined project "Enhancement of sustainable soil resource management in agriculture (LV-CLIMATE-0002)"

GT 14 - 1051 - P

COUPLING SENTINEL-2 TIME-SERIES AND LABORATORY VIS-NIR SPECTRA TO MAP SOIL ORGANIC CARBON CONTENT OVER SPANISH VINEYARD

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Agricultural soils in Central Spain, particularly in vineyards and olive groves, face severe degradation due to frequent erosive storms and conventional tillage, which significantly impact soil organic carbon (SOC) patterns [1], [2]. This study aims to map SOC content in a Spanish vineyard by combining Sentinel-2 (S2) time series with visible near-infrared laboratory spectra. The vineyard (ca. 82 ha) is located in Aranda De Duero, Burgos (150 km north of Madrid) under a continental Csb to semi-arid Bsh climate, with summer temperatures of 25-30°C and annual rainfall below 400 mm. Soils range from Calcaric to Aeolic Arenosols, with high coarse fragment cover in the southern part. Composite soil samples were collected from the 0-5 cm layer, at 60 sampling points. Each sample was air-dried (48h), sieved to 2 mm, and split into two subsamples: one for conventional SOC analysis and the other for spectral acquisition using an ASD Fieldspec3® with a contact probe. A S2 time series from 2022 to 2024 was compiled, excluding cloudy images and retaining only those from the vine dormancy period. Spectral indices were calculated, and bare soil pixels selected using a NDVI<0.3 + NBR2<0.175 mask. Equivalent indices were derived from pre-processed Lab spectra (e.g. continuum-removal). SOC prediction models were developed using three random splits (70% calibration, 30% validation) and different combinations of covariates: (1) S2 bands only, (2) S2 bands + S2 indices, and (3) S2 bands + Lab-derived indices. Four algorithms were tested: PLSR, SVR, RF and DNN. The best-performing model was used to produce a SOC map. Measured SOC content ranged from 2.9 to 22.9 g/kg (mean: 10.6 g/kg). The highest performance (RMSE = 3.2 g/kg, RPIQ = 1.82) was achieved with SVR using S2 bands + Lab-derived indices with continuum-removal. The resulting SOC map showed values from 6.9 to 16.7 g/kg, spatially influenced by coarse fragment cover, with underestimation in highly stony areas. However, predicted spatial patterns aligned well with observed variability and related soil properties. Future improvements could involve incorporating spatialized soil properties, particularly coarse fragment content, and using hyperspectral sensors such as EnMAP or PRISMA to enhance spectral accuracy.

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GT 14 - 1060 - P

SPECTRAL MODELS LEARN THE CONTEXT, NOT THE SOIL: RETHINKING SOC PREDICTION FROM LAB TO DRONE MEASUREMENTS UNDER FIELD CONDITIONS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 10. SOIL CARBON DYNAMICS AND STABILIZATION

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Predicting soil organic carbon (SOC) using spectral data remains a challenge in digital soil mapping, particularly under field-scale conditions where environmental factors (e.g., vegetation, moisture) can mask or distort soil reflectance [1]. These unstable conditions are a major obstacle to model generalization across space and time. In this study, we evaluated the ability of SOC prediction models, built from reflectance spectra from lab to field and drone measurements, to account for and generalize across varying environmental conditions, over a unique field plot structure located in Nouzilly (France). The experimental design consists of 3 replicates (block design) of 4 to 5 tillage practices (modality) within a single 11.25 ha field.

Two sampling campaigns (Oct 2024, May 2025) provided SOC (0-5 cm) and spectral data from lab, field, and UAV platforms at 75 sampling points. Co-variables such as moisture content and soil surface roughness were also collected. To assess model generalizability to new spatial and temporal conditions, we applied several data-splitting strategies: random splits, leave-one-block-out, leave-one-modality-out, and time-based splits between the October and May datasets.

Our results show that tillage modality alone induced significant SOC variability at the soil surface, with mean SOC ranging from 12.1 g/kg under conventional tillage to 16.7 g/kg under minimum tillage. Seasonal differences between October and May also contributed substantially to SOC variability, further complicating model generalization. In this context, co-variables related to soil roughness and moisture had no significant impact on improving model accuracy.

Model performance was highly sensitive to data-splitting strategy. Random splits gave overly optimistic results (R^2 = 0.75, RPIQ = 2.7 for field spectra), whereas leave-one-modality-out failed to generalize to unseen tillage practices, with most models showing $R^2 < 0$. Leave-one-block-out yielded reliable performance for laboratory spectra but failed for UAV and field data, especially under reduced environmental variability (e.g., in May or after NDVI-based filtering), with R^2 dropping from 0.72 to 0.28 for October UAV measurements.

These findings suggest that models often rely on indirect or ephemeral environmental features rather than direct or intrinsic spectral behaviour of bare soil resulting in unstable performance and poor transferability across space and time, even for similar soils.

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GT 14 - 1070 - P

ADDED VALUE OF PROXIMAL AND REMOTE SENSING FOR SOIL MAPPING AT FIELD SCALE COMPARED TO SIMPLE INTERPOLATION AND CONTINENTAL PRODUCTS

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Technological advances in the 21st century have enabled using both proximal and remote sensing for rapid estimation and high-resolution mapping of soil properties at different scales. While various soil sensing techniques are employed, a consistent framework to guide method selection and cost assessment remains lacking. To address this, a protocol was tested on several soil sensing techniques and covariates to select an appropriate combination of geospatial, multivariate, and machine learning techniques for the subsequent estimation and mapping of the physicochemical soil properties at different depths.. The protocol is based on an R script that integrates georeferenced soil information, field boundaries, remote sensing covariates (i.e., terrain, satellite, and UAV data), proximal on-the-go sensing (i.e., electromagnetic induction and gamma-ray spectroscopy), and point-based sensing (i.e., visible–near infrared spectroscopy (Vis-NIR), X-ray fluorescence (XRF), and time-domain reflectometry (TDR) to produce field-scale soil maps at 5-meter resolution. The semi-automated workflow begins with the creation of baseline maps generated through spatial interpolation of measured values. Coarser-resolution open soil datasets, such as SoilGrids 2.0 and other continental or national products, were also used as alternative baselines. These maps were evaluated through stepwise comparisons to identify the best-performing models based on combinations of input data and modeling techniques (i.e., multiple linear regression (MLR), partial least squares regression (PLSR), and Random Forest (RF). Model performance was assessed using Leave-One-Out (LOO) cross-validation and evaluated with RMSE, RPD, and R^2 metrics. The Relative Improvement Index (RI) was used to quantify performance gains across case studies. Applications were tested across diverse environmental conditions in Denmark, the Netherlands, Slovenia, Italy, and Türkiye. Outputs included soil property maps with associated uncertainty estimates. The proposed framework incorporates novel elements while also building established techniques. It evaluates how point-based data sources like XRF and TDR enhance spatial modeling and how Vis–NIR spectroscopy improves the predictive power of satellite data when co-registered with Sentinel-2 spectral bands. Results for organic carbon content at 0–30 cm depth show 10% to 25% of RI when combining remote and proximal inputs using RF or MLR , compared to simple interpolation (SI). Similar gains were observed for clay content, with RI increasing between 8% and 15%. More realistic spatial patterns were also obtained by proximal and remote sensing data compared to SI. Overall, the proposed framework offers a harmonized methodology and a practical roadmap for the precision agriculture sector, supporting informed decision-making through the integration of diverse data sources and modeling strategies.

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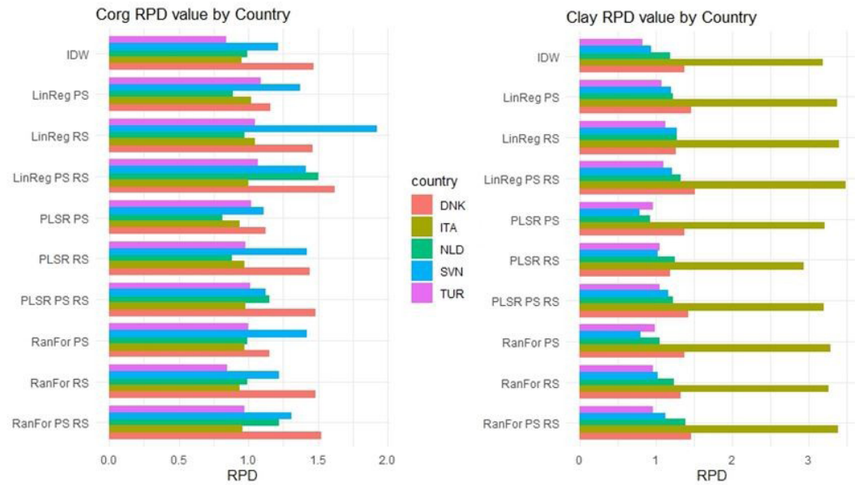


Fig. 1. Overall result accuracy by country based on RPD values for topsoil Organic Carbon content and Clay content. Abbreviations: IDW – Inverse Distance Weighting, LinReg – Linear Regression, PLSR – Partial Least Squares Regression, RanFor – Random Forest, PS – Proximal Sensors, RS – Remote Sensing



GT 14 - 1073 - P

SUPPORTING THE SUSTAINABLE MANAGEMENT OF AGRICULTURAL SOILS BY INTEGRATING NUTRIENT MANAGEMENT AND SOIL ORGANIC CARBON DYNAMICS MODELS WITH SENTINEL-2 SATELLITE DATA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The growing threats to soil health, particularly in regions increasingly impacted by climate change, demand innovative, science-based solutions. Organic amendments and the incorporation of residues from previous crops offer a pathway for improving soil health while enhancing soil organic carbon (SOC) content. On the other hand, precision agriculture incorporates site-specific management of fields, taking into account within-field variability tin the decision-making processes. Therefore, farmers, as key actors in this process, need operational tools that not only highlight potential risks, but also provide strategies to ensure the long-term soil productivity and resilience. Addressing these challenges requires (i) a comprehensive approach that bridges nutrient management practices with a deeper understanding of SOC dynamics and (ii) methods for mapping carbon inputs from crop residues biomass in fields.

To support this, the TUdi Decision Support Tool (DST) combines crop nutrient requirement assessments with SOC forecasting [1], using nutrient inputs as a factor in modeling SOC dynamics. This DST was designed as a practical decision-support tool for farmers and land managers, enabling informed decision-making to combat soil degradation and support sustainable land management practices. Total crop biomass can be predicted by the satellite-based biophysical variable the cumulative evapotranspiration (ETccum). ETccum maps are derived from NDVI time series and climate data [2]. Maps with a spatial resolution of 10×10 m can be obtained using Sentinel-2 data.

In this study, we implemented TUdi DST with crop residue biomass maps in commercial fields with more than 5 years of data, located in highly vulnerable regions of Europe to SOC loss, to evaluate cereal management. In the study fields, tailored strategies were explored to mitigate SOC decline and enhance C sequestration.

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GT 14 - 1074 - P

SPATIO-TEMPORAL ASSESSMENT OF CLIMATE REGULATION SOIL ECOSYSTEM SERVICE USING REMOTE SENSING DATA (SENTINEL 2) OVER TWO CONTRASTING STUDY AREAS IN MOROCCO

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 16. CONNECTING PEOPLE AND SOILS

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Soil provides several ecosystem services such as climate regulation through carbon storage, water retention, and the maintenance of agricultural fertility which are essential for human well-being and its socio-economic development [1]. Assessing as well as mapping these ecosystem services remain difficult, particularly in arid or Mediterranean regions where data is scarce and not exhaustive, and direct measurements are expensive. To address these limitations, several studies have adopted indirect approaches based on remote sensing [2], to estimate large-scale proxies of specific soil ecosystem services. This study proposes a simple and reproducible method for assessing soil ecosystem services, based on Sentinel-2 images and standardized spectral indices [3]. Indeed, a Principal component analysis was carried out to integrate five spectral indices: NDVI, BSI, NDTI, CI and B12 into a composite indicator reflecting the overall capacity of the soil to provide services. This method was applied over the baseline period 2016 to 2024 in two highly contrasting provinces of Morocco (Kénitra and Khémisset). The following approach provides a practical, low-cost, and reproducible solution for monitoring soil conditions and supporting decision-making in sustainable agriculture and natural resource management. The maps generated make it possible to visualize the spatial and temporal evolution of climate regulation services through carbon storage. The results indicate that the target ecosystem service is significantly increasing in the province of Kénitra, particularly in intensified agricultural areas, while a progressive deterioration is observed in the province of Khémisset, probably associated with a reduction in vegetation cover.

KEYWORDS

Soil ecosystem service, remote sensing, spectral indices, principal component analysis, composite indicator.

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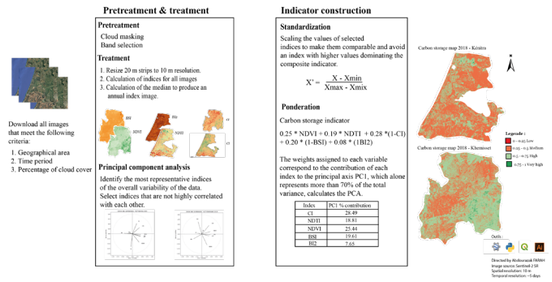
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Different stages of the methodology

GT 14 - 1077 - P

ASSESSMENT OF CLIMATE REGULATION ECOSYSTEM SERVICE USING INVEST MODEL IN TWO CONTRASTING STUDY AREAS IN MOROCCO.

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 16. CONNECTING PEOPLE AND SOILS

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Soil is a natural capital that provides several ecosystem services (SES) which support agricultural activities, biogeochemical cycles, and biodiversity conservation. The assessment of delivered SES remains a scientific challenge due to the lack of operational guidelines and the scarcity of exhaustive data. Although costly, the direct measurements approach of SES is the most relevant method for generating accurate quantifications. To overcome budgetary constraints and deliver SES quantifications, modeling approaches can be a good alternative. This study aims to characterize the spatio-temporal dynamics of climate regulation SES using the Invest model in two contrasting study areas in Morocco (Kenitra and Khemisset). To quantify the target SES, carbon storage was used as an indicator between 2017 and 2024. The main results showed that climate regulation SES thought carbon storage strongly depends on land use change, and a high spatial variability was highlighted over the two study areas. Moreover, an annual variation trend in carbon storage was also observed in the two regions, with a higher contrast in the Khemissat region. Overall, the Invest model allowed capturing the main spatio-temporal patterns of climate regulation SES over the Kenitra and Khemissat regions, which can be useful for policymakers.

KEYWORDS

Soil ecosystem services, carbon storage, InVEST model, Morocco.

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GT 14 - 1115 - P

SOIL TAXONOMIC AND TEXTURAL DIVERSITY AS PREDICTORS OF CROPPING INTENSITY: A CASE STUDY OF DIFFERENT AGRICULTURAL LANDSCAPES IN LATVIA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Data harmonization and assessment of soil taxonomic and textural diversity, as well as its mathematical quantification faces questions related to its relationships in different agricultural landscapes (formed by soil parent material of Quaternary geological deposits in boreo-nemoral region) with varying management and cropping intensity. Furthermore, the potential of soil diversity variables to predict cropping intensity is not well understood.

Therefore, the aim of this study - to assess the use of soil taxonomic and textural diversity as predictors of cropping intensity in two different agricultural landscapes - Taurene and Platone municipalities (characterized by different soil formation conditions, topography, and heterogeneity of soil cover, land-use structures and farming practices) in Latvia.

Data from large-scale soil mapping (1:10000) according to the World Reference Base for Soil Resources (WRB, 2022) system was used to calculate Shannon Diversity Index at landscape level and potential pedodiversity index (PDH) at a 30 × 30 m cell for assessment of soil taxonomic diversity at the municipality level. Cropping intensity was classified into 10 classes by using dominant crop types over a 9-year period (2015–2023) and calculating Mean Global Cropping Intensity (GCI) for each crop type, and cropping intensity classes were assigned in order of increasing GCI values.

The study applies multinomial logistic regression and random forest classification models to evaluate whether soil diversity indices at different levels of generalization and detail are effective predictors of agricultural cropping intensity.

The results indicate that the diversity of soil taxonomic and soil textural classes has a limited relationship with agricultural management cropping intensity. Results shows that notable patterns emerged for permanent grasslands and sown grasslands on arable land, where higher soil diversity was associated with an increased likelihood of these classes being identified. Although soil diversity indicators can contribute to predicting agricultural land-use intensity through machine learning models, effective prediction requires a structurally diverse agricultural landscape to ensure adequate representation across all intensity classes.

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GT 14 - 1120 - P

ASSESSMENT OF THE ACCURACY OF THE BOUYOUCOS METHOD IN SOILS WITH CONTROLLED TEXTURE

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The Bouyoucos method [1]is widely used for determining the texture of soil samples. It is a fast, cost-effective technique that provides sufficient accuracy for most pedological and agronomic studies. However, certain limitations have been noted, particularly a tendency to overestimate the sand fraction[2]. The procedure is based on Stokes’ Law, which relates the diameter of a particle to its settling velocity in a fluid. Typically, the sample is mixed with water and sodium hexametaphosphate. Once dispersed in the fluid, hydrometer readings are taken at 40 seconds (to estimate the combined silt and clay fractions) and at 2 hours (to estimate the clay fraction), from which the textural classification is derived[2]. It is important to consider that the dispersion process can be affected by factors such as the presence of organic matter or soluble salts.

This study aims to identify the possible causes limiting its accuracy, and propose adjustments for improved application. To this end, we used the sample set collected for the European project SanchosThirst, which includes samples from 15 vineyard and olive grove plots in various Spanish provinces, each under two management practices (cover cropping and traditional tillage). The wide range of physicochemical soil properties within these samples provides a suitable basis for assessing potential deviations in the method. Additionally, control samples of known texture were prepared using pre-homogenized sand, silt, and clay fractions.

This abstract presents the observations made on the control samples using scanning electron microscopy (SEM) and binocular microscopy. The suspension of the control samples was collected at the same times as the hydrometer readings for analysis.

The measurements obtained from the control samples showed a deviation from the expected volume distributions, confirming an overestimation of the clay content when applying the formula to the hydrometer readings. Observations under the binocular microscope and SEM revealed textures consistent with those predicted by Stokes’ Law. Therefore, the discrepancy in the data likely stems from the parameters used in the calculation formula of the Bouyoucos method.

This study represents a first step toward adjusting the Bouyoucos method to yield more accurate and reliable data, while preserving the undeniable advantages this technique offers for soil texture analysis.

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GT 14 - 1124 - P

REGRESSM: A SOFTWARE TOOL FOR DOWNSCALING THE SMAP L3 SOIL MOISTURE OPERATIONAL PRODUCT UTILIZING THE TS- VI FEATURE SPACE AND SENTINEL-3 DATA

GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING / GT 08. SOIL-PLANT-WATER INTERACTIONS

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RegreSSM is a software tool that offers automated and reproduceable workflows for processing SMAP L3 Surface Soil Moisture (SSM) products by the fusion of optical and thermal data retrieved from Sentinel-3 platform. It integrates pre-processing, data fusion, and output generation into a modular, automated workflow, minimizing the need for manual intervention. The downscaling method is based on the well-established properties of the Ts/VI feature space. The RegreSSM has been developed in python programming language as a stand-alone application and can be executed in any operational system (OS). The tool was designed to automate the downscaling of satellite-based soil moisture data through an efficient and user- friendly processing pipeline. Its flexible architecture allows easy adaptation to various geographic regions and datasets, making it suitable for both research and operational applications. The tool's practical application is demonstrated over the Iberian Peninsula, where validation ofthe SMAP L3 product performed for all calendar year 2022 using in-situ observations from the REMEDHUS operational network stations. Results showed a satisfactory retrieval of SSM with a small average bias of 0.01 m 3 /m 3 , a MAE of 0.06 m 3 /m 3 and a RMSD of 0.07 m 3 /m 3 . Results obtained herein were also comparable to the validation metrics reported for operational RS-based SSM products, with typically reported uncertainty of 0.04 m 3 /m 3 . The availability of RegreSSM to the SSM users' community consists an mportant step towards the standardization of downscaling procedures as well as bridging the spatial gap of existing operational SM products to the requirements of the fine-scale applications. It also contributes towards advancing the deployment of geo-processing tools utilizing the synergies between state-of-the-art methods and RS data available today from the most sophisticated satellites in orbit.

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GT 16. SOIL LITERACY EDUCATION & ART

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER



GT 16 - 111 - O

BRIDGING CITIZEN SCIENCE GENERATED DATA AND SOIL LAB ANALYSES: UNDERSTANDING THE VARIABILITY AND INSIGHTS

GT 16: SOIL LITERACY EDUCATION, & ART / GT 09. SOIL HEALTH

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ECHO is a Horizon Europe project with the aim to engage European citizens in soil protection and restoration by enhancing their knowledge on soil health. ECHO empowers citizens by actively involving them in soil science through data collection across all EU countries between 2024-2027. Citizen scientists in ECHO contribute to generate data on the eight soil health indicators outlined in the Mission Soil Implementation Plan (presence of pollutants, soil organic carbon (SOC), soil structure, soil nutrients and pH, soil biodiversity, vegetation cover, forest cover and landscape heterogeneity). The data collected by citizen scientists will be uploaded to the ECHOREPO, a long-term open access repository linked to the EU Soil Observatory (EUSO). This ensures that citizen science data is accessible to scientists, citizens, farmers, stakeholders and other end-users, supplementing existing datasets on soil health across Europe.

Citizen scientists participating receive the ECHO toolkit containing easy-to-use, low-costs tools, along with featured protocols and training resources to guide them in soil sampling. However, despite standardized protocols, the simplified methods used for on-site soil health assessment may be less accurate than laboratory-based analyses using analytical instruments. Therefore, we aim to validate citizen science-generated data (CSGD) from approximately 100 soil samples selected to be representative of the main land-uses and soil types covered by Italian citizens. For these samples, we then compare on-site assessments of pH, SOC and texture with results from laboratory methods.

While soil pH, SOC and texture are measured on-site by citizens using pH strip method, soil colour estimation, and the feel method, laboratory analyses follow standard ISO methods: pH will be determined using the 1:5 soil-to-water ratio method, SOC will be analysed by dry combustion and texture by sieving and sedimentation.

Comparing CSDG with laboratory analyses will enable to assess variability between the approaches and inform CSDG integration with European soil health monitoring programmes. Additionally, these results can be compared with existing soil and environmental datasets, such as LUCAS, to better understand where variability and complementarities occur.

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GT 16 - 315 - O

SOILSCAPE : SOIL ILLUSTRATED BY SCIENCE AN ART FOR PUBLIC EDUCATION

GT 16: SOIL LITERACY EDUCATION, & ART / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The European project SOILSCAPE (2024-2028), coordinated by AFES, mobilizes arts, culture, and civil society to reimagine soil preservation across Europe. With 18 partners from 10 countries, this transdisciplinary consortium brings together scientists, artists, and local stakeholders through a unique approach combining artistic creation, soil science, and citizen engagement.

With a 5,9 € million budget, SOILSCAPE unfolds in four main phases. The diagnostic phase will analyze societal perceptions of soils and catalog existing artistic expressions. The co-construction phase will establish a pan-European network connecting eight national art-science networks. The main action phase will support 36 original artistic initiatives (installations, participatory theatre, etc.) while developing innovative educational tools. In the scaling-up phase, successful practices will be adapted and expanded across broader contexts.

Among the project's flagship initiatives is the creation of national Soil Orchestras in eight countries. These structured platforms—composed of core groups from research, the arts, and civil society—will not only organize national soil festivals but also serve as sustainable bridges between artists and scientists. By fostering long-term collaboration and shared creative processes, these Orchestras aim to strengthen interdisciplinary relationships, stimulate cultural dialogue on soil issues, and serve as inspirational models for other countries to replicate.

Key outputs include a Soil Literacy portal, multilingual educational portals,to promote the initiatives on soil knowledge and preservation. The project will also host artist-researcher residencies and enhance cooperation with international initiatives such as UNESCO's Soil and Memory programme.

Scientifically, SOILSCAPE will pioneer methodologies to assess how artistic approaches influence environmental behaviors. These advances will directly inform public policies on sustainable soil management, aligning with the EU Soil Mission and Global Soil Partnership.

By bridging science, art, and society, SOILSCAPE offers a groundbreaking pathway for soil preservation in Europe and beyond.

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GT 16 - 437 - O

OUTDOOR SOIL EDUCATION: LESSONS FROM SOIL SUMMER SCHOOLS

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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Soil is a complex natural system characterised by diverse physical, chemical and biological properties. Although soils provide essential ecosystem services that sustain life on dry land, they are generally little recognised by the public, experts in other disciplines, politicians and policy makers, and even environmentalists. Although soils are an important natural resource for environmental health and human well-being, they are still underrepresented in primary and secondary school curricula. In order to promote environmental protection and sustainable development, it is crucial to increase knowledge about soils and to teach it to students — the future decision-makers - at an early stage.

Teaching about soils requires a special approach. Classroom teaching alone is not enough to convey the complexity and importance of soils. Outdoor teaching, where students can observe, analyse and discuss morphological, physical, chemical and biological properties directly on open soil profiles, is more engaging and effective. However, organising a multi-day outdoor soil science summer school can be a logistical challenge.

This article describes the implementation and experiences of two Soil Summer Schools (SSS), which were carried out as part of EU soil research projects in a Slovenian mountain area. Each SSS lasted five days and involved students from secondary schools in Slovenia and Slovenia, Liechtenstein and Italy respectively. The participants were divided into international groups, each supervised by a soil expert. The programme began with an introductory lecture on soil science, followed by field work. The students excavated soil profiles, observed and described morphological characteristics, measured soil acidity and penetration resistance and discussed the role of different soil types in the environment. Soil experts were on hand to explain the environmental functions and capabilities of each soil and relate them to the landscape, vegetation and biodiversity. Afternoons were dedicated to group presentations and discussions on the results. The paper also highlights some specific adaptations, teaching methods and materials used in the SSS.

Student feedback confirmed the success of the programme in transforming the topic of soil from a marginal and unrecognised topic to one of interest. The SSS significantly increased student awareness of the importance of soil and provided valuable insight into best practises for outdoor soil education, including safety protocols and effective teaching methods.

KEYWORDS:

teaching soils, soil awareness raising, outdoor teaching

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GT 16 - 561 - O

FORUM NANTESBUCH - LIVING SOILS: AN INITIATIVE OF THE FOUNDATION ART AND NATURE FOSTERING SOIL LITERACY AND STEWARDSHIP ACROSS SOCIETY

GT 16: SOIL LITERACY EDUCATION, & ART / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soils are a vital and non-renewable natural resource for current and future generations. Their sustainable use and protection are prerequisites for addressing global challenges such as climate change, biodiversity loss, and food security. Despite extensive knowledge about soil systems, global climate change and anthropogenic influences have increasingly threatened important soil functions. However, public discourse, policy decisions, and everyday practices often fail to reflect the importance of soils and to bring sustainable soil management into practice.

Since 2012, the foundation Art and Nature (www.nantesbuch.de) has offered spaces and interdisciplinary programs for engaging with art and culture as well as nature and landscape. In 2023 it has made soil a central focus for its future thematic development and launched the soil initiative “Forum Nantesbuch – Living Soils” to foster soil literacy and stewardship across society.

Forum Nantesbuch combines artistic, scientific, and other societal perspectives and builds on an inter- and transdisciplinary approach. It aims to complement existing institutions and initiatives by offering open spaces for dialogue, reflection, and new alliances - building on synergies and evolving into a cross-cutting and independent platform. A particular emphasis is placed on artistic and cultural approaches - whether from ecological, health-related, philosophical, or socio-economic aspects.

The initiative brings together stakeholders from science, practice, arts, education, civil society, and communication to explore and understand the importance of soils from multiple viewpoints and to engage audiences who may have had little contact with the topic of soils so far. This transdisciplinary approach allows in-depth discourses to address challenges and develop solutions for “soil positive management.”

Still in its development phase, the Forum Nantesbuch focuses on building a resilient structure with long-term impact. Activities to date include (a) the establishment of a competence network with stakeholders from diverse sectors, including science, practice, arts and other disciplines, (b) the implementation of an annual Forum Nantesbuch as a transdisciplinary gathering for dialogue and collaboration, (c) the integration of diverse soil-related themes into the foundation’s cultural program, and (d) scientific partnerships and monitoring activities on the foundations premises, which functions as a living lab.

This presentation outlines the concept and working principles of Forum Nantesbuch and provides insight into its early developments, recent key activities, and future ambitions.



GT 16 - 624 - O

LASOL: A LIVING LAB TO HELP INTEGRATE SOIL PROTECTION INTO SPATIAL PLANNING AND CONSTRUCTION.

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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In Switzerland, despite numerous detailed tools to help apply soil protection in construction, there is a lack of application of good practice. In the area of land use planning, However, the Swiss soil strategy has set clear objectives, including the integration of soil value into spatial planning. Soil protection groups note that these objectives have largely not been achieved. Why this failure? What are the obstacles and the needs of the various stakeholders? Where are the opportunities for soil protection? What tools are needed?

A living lab (LASOL) has been set up to answer these questions. It is focusing on a 60-hectare land development project called Chamblioux-Bertigny, in Fribourg County, including among 20 ha in SDA, which includes the construction of a hospital, a motorway cover, a neighborhood development and an urban park. These different projects are at very different stages of the process, and are not under the control of the same project owner. LASOL brings together project owners, soil protection supervisory bodies, spatial planning and soil specialists, a sustainable development foundation and facilitators.

The ambitions of the project are to identify the key moments for soil protection in the timeline of the various projects, to develop a common lexicon for talking about projects and soil, to identify the key people and their needs, so that soil protection and the transfer of information can take place through the chain of players. Finally, existing tools are evaluated or new tools are developed to help achieve these objectives.

The 2 years of LASOL's life have revealed first stumbling blocks: the lack of mutual understanding of the language specific to the different fields, their processes and the levels of constraints relating to the decision-making stages. The second difficulty lies in the different timeframes of the projects, despite the fact that they cover the same territory. Mapping tools of stakeholders are proposed to both identify the difficulties and attempt to resolve them. Soil quality index maps are evaluated to help take into account the value of soil in development projects. Results are ealuated during a urban planning competition, realized in two steps. The first starts before LASOL and the second during LASOL existence. Thematic soil maps (water regulation and heat regulation capacity for exemple) and several additional, were included in the technical documents forthe second competition step.The technical specification documents were analyzed using lexical analyses. The results showd thatthe occurrence of the word "soil" into the technical specification document establishedin the first competition showed 2 occurrences of the word "soil" while 28 in the second competition. Soil hasbecome a theme for the competition organizers among urban planers.

A living lab and thematic soil maps revealed a high potential to help urban designers to include soil into their decisions.

GT 16 - 652 - O

EDUCATIONAL AND OUTREACH ACTIVITIES OF THE TERRITORIAL DELEGATION OF THE SPANISH SOCIETY OF SOIL SCIENCE (SECS) IN GALICIA

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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The Spanish Society of Soil Science (SECS, www.secs.com.es), founded in 1947 by the Spanish National Research Council (CSIC), aims to promote the study and advancement of Soil Science. The Territorial Delegation of the SECS in Galicia (SECS-Galicia), established in 2009, works to strengthen SECS's presence in the Galicia region (NW Spain), foster collaboration among its members, and raise awareness across society about the critical importance of soils and their protection. The delegation leads diverse projects, with a strong focus on educational initiatives. Through cooperation agreements with educational institutions, the Galician Government, and international Soil Science Societies, SECS-Galicia engages students across all levels — from primary and secondary schools to universities — using innovative teaching materials that support educators and spark student interest in soils as a non-renewable natural resource.

This session will highlight recent outreach projects and events, including:

- Annual activities for SECS members of all ages featuring expert talks and field trips to pristine, degraded, and restored agroforestry ecosystems (impacted by wildfires, intensive agriculture, pollution, etc.).
- Events and talks held in collaboration with farmer associations, museums, nature organizations, and cultural associations across urban and rural areas.
- Annual celebrations and competitions for World Soil Day (5 December) and the International Decade of Soils (2015–2024).
- Educational comics such as Living in the Soil (with lesson plans in 11 languages) and Let's Discover Soil Biodiversity (available in four languages).
- Art and soil exhibitions including Soil: Art Painting with Soils (works by José Caballo), Making Soil Visible, A Three-Dimensional Representation of a Living Soil, The Game of Soil, and the multilingual bookmark A Living Soil (available in six languages).
- Visits to the Permanent Soil Room at the Natural History Museum of the University of Santiago de Compostela.

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GT 16 - 662 - O

LOCAL KNOWLEDGE OF SOIL HEALTH IN SMALLHOLDERS AGROECOLOGICAL FARMING SYSTEMS OF THE ANDEAN FOOTHILLS

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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Agroecology is seen as a way to make agriculture more sustainable by using local knowledge and adapting to local conditions. But in many cases, the knowledge farmers already have—especially about soil—is not well understood or included in the design of agroecological systems. This study looks at how smallholder farmers in Curarrehue, a rural area in southern Chile, understand and manage soil health. The area includes diverse cultural backgrounds and is closely connected to native forests and traditional farming.

We used a qualitative approach combining 13 semi-structured interviews and two participatory workshops with farmers. Most participants are small-scale producers who grow food for self-consumption and local exchange, often with mixed crops and animals. Many are older adults, with strong ties to their land and community, and limited access to formal markets or extension services. Several are part of the national Indigenous Development Program (PDTI). Interviews focused on how they define healthy soil, what signs they look for, and which practices they use. In the workshops, participants shared how they imagine a healthy soil and how they would like their farms to be in the future. We analyzed the data using thematic coding to find common patterns and ideas.

Farmers described soil health using indicators such as color, smell, texture, moisture, the plants that grow, and visible soil organisms. These signs are part of a broader view that sees soil as something alive, with a role in supporting family wellbeing and healthy food. Common practices include composting, using manure, rotating animals, intercropping, and letting the land rest. These practices are shaped by the landscape, local climate, available resources, and support from programs like PDTI.

Our results show that farmers' knowledge of soil is consistent and based on careful observation. This kind of knowledge can be a valuable resource, especially in places where scientific monitoring is limited. By bringing together ideas from soil science, agronomy, and anthropology, this study offers practical lessons for supporting agroecological transitions that are not only environmentally sound but also socially fair.

Recognizing the role of smallholder knowledge can help make sustainability efforts more inclusive and better adapted to real-world farming conditions.

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GT 16 - 681 - O

BUILDING KNOWLEDGE ABOUT THE SOILS AT THE LOCAL SCALE: THE CASE OF ORDUÑA (SPAIN)

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Soil represents a fundamental component of natural capital essential to human well-being, through its diverse properties and multifunctionality, it contributes directly and indirectly to the provision of ecosystem services (ES) to society at various levels [1,2]. Understanding the characteristics and properties of soils in a territory is crucial for characterising how soils function and the ES they support [3]. This knowledge also helps identifying processes that may lead to soil degradation, known as soil threats, which can compromise soil functions and ES they provide [4].

This study was conducted at the local scale in the municipality of Orduña, Basque Country (Spain), and focuses on generating information and mapping related to local soils. The main objectives are, on the one hand, to highlight the role that soils play in this territory, and on the other, to produce essential baseline information to support the assessment of the sustainable provision of key soil-based ES and their resilience to the pressures of global change. The project was conducted in three phases:

1. Generation of detailed foundational information on soils and development of a soil map for the local territory (3300 ha), serving as a core source of knowledge on local soil characteristics.

2. Adaptation and application of the Land Capability Classification (LCC) system to the municipality, providing a simplified view of the soil map from the point of view of agricultural production.

3. Assessment and mapping of a set soil-based ecosystem services provided by the soils within the municipality, recognizing and valuing soils for the essential role they play in sustaining society.

The soil map allowed the definition of 8 cartographic units, distinguishing soils from the high areas of the landscape (around 1000m altitude) to those at the bottom of the main river valley crossing the territory (around 260m altitude). The adaptation of LCC included the study of soil properties such as depth, texture, stoniness, organic matter, water retention and salinity, as well as other properties associated with the territory such as climate and topography. Three provisioning ES (food supply, freshwater supply and timber supply) and 4 regulating ES (habitat maintenance, climate regulation, water regulation and soil fertility maintenance) were considered and mapped.

Emphasizing the importance of a high-quality base knowledge, the development of this work can lead to connecting people and soils by fostering awareness and engagement with this vital natural resource, as well as to the establishment of a baseline to support the design of effective strategies for controlling soil degradation and improving soil health.

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GT 16 - 729 - O

SOIL: OURINVISIBLEALLY – PROMOTING SUSTAINABLE SOIL MANAGEMENT THROUGH SCIENCE AND ART

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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Background: The overuse of resources and the effects of climate change have been exacerbating soil degradation in the Alpine region, calling for a shift in land management practices. Although solutions and relevant data already exist, change is slow and sporadic – in part due to low levels of soil literacy and the lack of efficient dissemination of soil knowledge. But which other factors can be held accountable? SOIL:OurInvisibleAlly is a 3-year project (2024-2027) funded by the European Union's Interreg Alpine Space Programme that aims to answer the above question, while also addressing the issue of inadequate soil literacy. Through interdisciplinary workshops and cultural events, the project promotes sustainable soil management (SSM) practices and raises public awareness about the importance of healthy soils.

Approach: To build a foundation, the project collects and synthesizes knowledge on best soil management practices (SSM tools) in the Alps and partners with different pilot sites (12) showcasing these practices in different land-use contexts. Both steps are informed and motivated by the need to preserve or, if already diminished, restore soil ecosystem services (SESs). Simultaneously, the project focuses on distributing soil knowledge interactively in two distinct ways by 1) training actors equipped to further disseminate learnings and 2) catching public attention by means of cultural events that combine scientific information with interactive aesthetic experiences. Such events have the potential to make science more inclusive, accessible and appealing to audiences that would otherwise "steer clear".

Framework: The graphic representation of the project's conceptual framework connects soil natural capital, soil functions and soil ecosystem services (SES) by emphasizing interdependencies between them in the context of sustainable soil management (SSM) and soil resilience. The framework guides project activities by highlighting the relationship between human interventions (via soil management practices) and soil resilience, thereby making the case for SSM. By implementing SSM, stakeholders can positively affect soil properties, which ensures the long-term stability of soil functions and therefore also the provision of SESs. Clear linkages among elements of the conceptual framework enable a joint understanding of the basic principles of human-soil interaction and promote the implementation of SSM practices.

During the presentation, we will present the project's conceptual framework and expected results, as well as elaborate on the above intervention logic by highlighting examples of each activity type, showcasing preliminary findings and presenting ways of including the topic of soil in artistic and cultural events.

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Lead partner: https://www.gozdis.si/en/active-projects/soil-our-invisible-ally/

Associated website & content: https://www.alpinesoils.org/?page_id=16

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GT 16 - 753 - O

TALES OF THE SOIL: STORYTELLING AS A WAY TO INCREASE SOIL LITERACY

GT 16: SOIL LITERACY EDUCATION, & ART / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Soils are omnipresent and essential for life, and yet most people are unfamiliar with the resource. The complexity and hidden nature of soil is only partly the cause for lack of awareness of soil as a resource and its functions. When people explore nature, including enjoy their own garden, one sees the flora and fauna, but not the part below the surface. Since not many schools include soil in their curriculum, most people lack a knowledge framework, a perception and terminology for soils; they are soil illiterate. The general lack of perception of soils means that sensory information on soils is not processed to the extent that it leads to understanding and awareness. In other words, people that have no education or prior knowledge in soils need to be introduced to it to be able to engage in it and appreciate it. This can be achieved amongst other by storytelling.

The World Soil Museum serves as an educational hub for researchers, students, and policymakers to learn about soil classification, management, and sustainability. The museum contributes to global soil awareness by preserving and documenting soil samples from different regions in the world. It showcases the diversity, functions, and importance of soils worldwide through interactive exhibits and real soil monoliths. Soil monoliths are undisturbed, vertical soil samples of about 1.5 m depth. They present the soil very close as to how they are seen in a profile pit in the field, with the layering, colours and structure of the soil. The aim is to engage as many people as possible on the topic of soils, their functions, and their importance for society and the environment, both at the museum and online. The gap between visitors, the topic of soils and the monolith collection is bridged through guidance and tours and supported by digital (online) media and audio-visual material. Storytelling is used to bring soils closer to people in a way that it inspires and is more easily remembered so that it will be passed on in communication between people. Stimulating stories on soils are told and placed in the context of society. They stick to the mind as they link with perception and understanding of the public on topics such as people, history, land management, food security, and climate change. The layers in one of the soils in the museum, for example, is connected to an eruption that lead to human disaster, environmental change, and is connected to the start of the French Revolution. That and other examples of soil stories will be provided and to explain how that stimulates learning and dialogue with museum visitors.

KEY WORDS:

Storytelling, Dialogue, Digital media



GT 16 - 761 - O

RAISING SOIL LITERACY TO CATALYSE SOCIETAL CHANGES: THE CURIOSOIL APPROACH

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Despite being fundamental to human survival, soils receive insufficient attention in policy, education, and public awareness. More than 60–70% of EU soils are unhealthy, highlighting the urgent need to prioritize soil education amid escalating challenges of degradation, climate change, and food security. Within this context, the CURIOSOIL project aims to understand what the soil literacy levels are among the EU population and ascertain how educational strategies can effectively raise awareness of soil health amidst global environmental challenges and catalyse societal changes towards soil protection. CURIOSOIL will assess the soil literacy baseline of citizens through a robust Soil Literacy Assessment Framework (SLAF), aligned with key European frameworks such as GreenComp [1] and PISA [2]. To address identified soil-related educational gaps, educational resources as well as a "Soil Curiosity Kit" featuring interactive, multisensorial materials will be co-developed with key stakeholders, and the impact of these interventions will be assessed through a second round of the SLAF at the project's conclusion.

To achieve these objectives, the Theory of Change (ToC) [3] approach is applied in CURIOSOIL. This approach will define long-term goals for raising soil literacy and track societal changes and the impact of project initiatives through a set of Indicators of Change (IoC), developed to assess quantitative (e.g., % awareness, participation rates) and qualitative changes (e.g., shifts in values, policy adoption). These long-term goals aim to embed soil literacy across knowledge, attitudes, and skills, driving a societal shift toward valuing, protecting, and restoring soils. The application of the ToC approach will include 4 main steps:

• STEP 1: Definition of long-term goals for raising soil literacy through education, based on the SLAF.

• STEP 2: Identifying assumptions and developing IoC for the long-term goals.

• STEP 3: Backwards mapping and connecting CURIOSOIL outputs and expected outcomes in relation to IoC.

• STEP 4: Completing the outputs, expected outcomes, and impacts framework.

This approach will be supported by multiple Communities of Practice across Europe – including educators, soil experts, policymakers, and soil stewards to ensure that outcomes are culturally adapted, widely applicable, and sustainable in the long term.

ACKNOWLEDGEMENTS

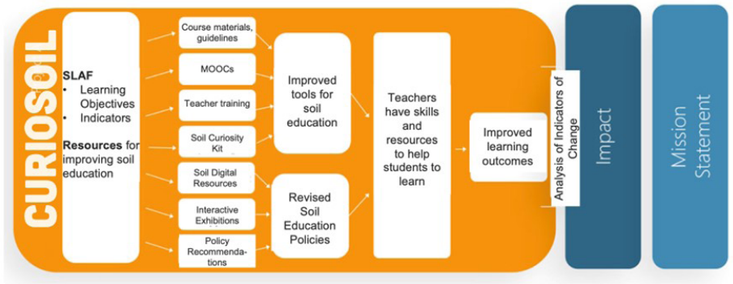
The authors acknowledge co-funding from the European Union under the Horizon Europe Programme, through the project CURIOSOIL Grant Agreement No. 101112875 and the financial support of CESAM (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020) by FCT/MCTES, through national funds. We also thank project partners for their contributions.

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Theory of Change (ToC) in CURIOSOIL project

GT 16 - 905 - O

THE BOOK: SCANNING ELECTRON MICROSCOPY (SEM) OF SOILS AND OTHER MATERIALS. ATLAS OF IMAGES

GT 16: SOIL LITERACY EDUCATION, & ART / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Introduction. There is little specific literature on Scanning Electron Microscopy (SEM) of materials, and specifically of soils; i.e., the systematic study of soil SEM fabric has not been undertaken. In SEM microtextures of quartz grains, there has been greater progress, although little of it is applicable to atmospheric quartz. SEM analysis of biominerals does provide results of interest. However, in all the topics mentioned above, there is a gap in the specific methodology for the description, analysis, and interpretation of SEM data.

Material and Method. To address the above, this communication presents the publication of a treatise by Editorial Universidad de Granada (Delgado & Martín-García, eds., 2024) [1] (Figure 1), comprising thematic chapters from specialists from the universities of Granada (UGR), Seville, Autónoma de Madrid, Complutense de Madrid, Barcelona, Jaén, Almería, and Santiago de Compostela (Spain); Aveiro and Coimbra (Portugal); Udine (Italy); and Oslo (Norway). It is dedicated to a prominent figure in microscopy at UGR, Professor Miguel Delgado Rodríguez (1921–2003), who introduced SEM to the Faculty of Pharmacy at UGR.

Results. The work is organized into two parts: I – General and technical aspects, and II – Applications. Atlas of images. The book presents forty chapters distributed in the following sections: I.1 – Fundamentals, I.2 – Technical aspects, II.1 – Approach to the ultramicromorphology of soils, II.2 – Soil granulometric fractions, II.3 – Mineral materials of sanitary and industrial interest, II.4 – Biomineralizations, II.5 – Aeolian particles and atmospherogenesis. Because of the profusion of SEM images included (~350), the book has been subtitled Atlas of images, which is one of its strengths, offering unique findings and procedures. The figure captions are self-explanatory and descriptive, with symbols included in the images that were standardized at the beginning of the book. Heuristic (binary) diagrams were also added to highlight interpreted features. Detailed observation of selected areas is another resource used, as well as the inclusion of EDX spectra with the elemental composition of highlighted zones. With this set of interpretative tools, we aim to enhance the understanding of visual information from SEM images—an essential yet underexplored aspect in soil and material studies.

Conclusion. Scanning Electron Microscopy (SEM) and its associated techniques have proved to be essential for the study of soils and other materials, revealing relevant aspects of an organizational, compositional and/or functional nature.

KEYWORDS

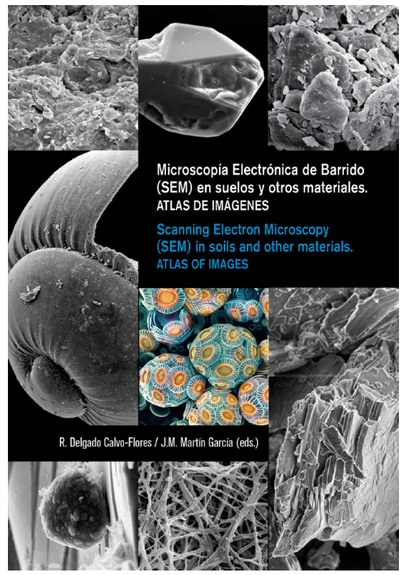
Scanning Electron Microscopy, Soils, Materials.

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GT 16 - 436 - F + P

RAISING SOIL AWARENESS IN PRIMARY AND SECONDARY SCHOOLS THROUGH INDOOR WORKSHOPS - DESIGN AND LESSONS LEARNED

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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Soils are the most important natural resource supporting life in terrestrial ecosystems, and yet they remain severely underrepresented in environmental education. Despite providing vital ecosystem services (food, timber and other biomass, regulating surface runoff, filtering and enriching drinking water, regulating (micro)climate, providing habitat of extreme soil biodiversity, etc.), soils continue to receive little attention in school curricula worldwide. Recognising this gap, two models of soil awareness rising workshops for primary and secondary school levels were developed and tested within the CURIOSOIL project. The main aim of the models was to contribute to hands-on soil education, increase soil literacy and environmental awareness through engaging, adaptable and all-weather indoor teaching methods.

Two different workshop formats were developed: a one-hour module and a comprehensive five-hour event. The shorter workshop consists of an introductory presentation on the role of soils in the environment, followed by a quiz with up to ten questions to deepen the newly acquired knowledge about soil. This format is designed to be flexible and easy to integrate into different grade levels. The extended and more immersive five-hour workshop is designed to spark curiosity and deepen students' understanding of the crutial role of soils and ecosystem services. It consists of four integrated work packages: i) a basic presentation on soil and its properties, ii) a short laboratory soil research entitled "Look in the soil!" using accessible tools and methods, iii) a group-based quiz on soil in the environment and iv) a work package linking soils and art through painting activities. Students are assigned specific roles, such as leaders, soil science promoters, whisperers and cheerleaders, each responsible for different tasks. This motivates them to deepen their engagement and lead and steer the workshop under the supervision of soil experts/scientists. The workshop models allow for experimental and hands-on learning, peer teaching, interdisciplinary engagement and relaxed competition.

This article presents findings from multiple implementations of the models in primary and secondary schools and summarises best practices for organising similar educational interventions. The feedback from students and also teachers was very positive, indicating increased curiosity, a better understanding of soil science concepts and a greater appreciation of the role of soil in the environment. While the research and evaluation phase of these activities is still ongoing, initial implementations suggest that more interactive teaching methods are more effective compared to traditional, lecture-based teaching approaches. Future upgrades of the models will focus on refining the workshop components and systematically evaluating their long-term educational impact.

KEYWORDS:

soil literacy, soil education, teaching methods, workshops

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Pupils in Soil Laboratory

GT 16 - 166 - P

COMIC "LIVING IN THE SOIL": AN INTERNATIONAL PROJECT OF THE INTERNACIONAL DECADE OF SOILS 2015-2024 TO AWARENESS SOIL IMPORTANCE WORLDWIDE

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The soil is a hidden resource covered by the vegetation and, hence, is very little known to the public. For many years, the scientific community was considered the soil as an inert system. However, in the last decades, it is recognised as a living system providing ecosystemic services needed to maintain life on our planet. In fact, the soil is the habitat of a huge diversity of organisms of different sizes, around 25-60% of terrestrial biodiversity. In accordance with this new paradigm, in 2015 the comic "Living in the soil" was published by the Spanish Society of Soil Science (SECS) and the Spanish National Resource Council (CSIC), in both Galician and Spanish, to celebrate the International Year of Soil. The protagonists of the comic "Living in the soil" are a snail, an earthworm and a mole that inhabit the soil, as well as a group of young people who, trying to solve a problem of soil use management that occurs in a little village, show us several important soil aspects (formation, components, functions, threats, degradation, protection and restoration).

In 2015, the comic was recognised by the FAO as an excellent didactic resource to make visible the living soil in our society, and hence, it was included in the repository of campaign materials to celebrate World Soil Day, 5 December. Subsequently, to commemorate the Decade International of Soils (2015-2024), the comic was adapted to the specific scenarios of the areas/countries where it was edited and translated to English as well as other languages (Catalan, Italian, Polish, Chinese, German, Hebrew, Portuguese and French) for broadcasting it both nationally and at the international level. The Spanish, Italian and Catalan versions were even re-edited. All comic versions were edited in both paper (more than 80,000 copies) and web format; the latter are available, among others, on the FAO (1) and SECS (2) web pages.

Since 2015, the comic has been used in many activities and projects, performed in various institutions (educational centres, museums, natural parks, nature associations, soil-related events, etc.), with a great success (for example, "Proyecto Ciudad Ciencia: Vivir en el suelo ¿Sería posible la vida en el planeta sin el suelo", SECS and CSIC; "Vivere nel Suolo: Giornata di Legalitá Ambientale", SECS, SISS and Parco dei Nebrodi; and the comic project "Let's go to discovery soil biodiversity", MBG-CSIC, SECS, SIPE and ESSC). The outcome of these educative/outreach projects showed clearly the great potential of the comic "Living in the soil" as an innovative and attractive publication of great interest to disseminate and raise awareness worldwide about the importance of this non-renewable resource for maintaining life on the planet.

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GT 16 - 278 - P

CHALLENGES OF SOIL EDUCATION IN THE SURVEY RESEARCH OF THE LOESS PROJECT

GT 16: SOIL LITERACY EDUCATION, & ART / GT 09. SOIL HEALTH

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Soil is currently one of the most underestimated resources in urban areas. Effective use of soil within the framework of urban management policy is necessary if we want this valuable resource to contribute to improving the quality of life. Therefore, rational land management should take into account all soil functions: production, habitat and retention, as well as reuse and recycling of soil. Such an approach requires appropriate public knowledge about soil. Knowledge about soils is usually acquired in primary and secondary schools and as part of studies in fields closely related to soil, including: horticulture, agriculture, forestry, geology, environmental protection.

As part of the European LOESS project, an online survey was conducted among educators of its partner network. The survey aimed to identify needs in teaching issues related to soil health. The LOESS project focuses on increasing soil knowledge in Europe, while engaging multiple actors, stakeholders and target groups related to soil education. LOESS brings together 20 partners from 15 countries to provide an overview of the current state of soil education at different levels of education in Europe. Data collection started on 7 May 2024 and ended on 29 July 2024, with a total of 2644 responses received, of which 1302 were complete and used for analysis. The questionnaire consisted of 33 questions. Response rates varied significantly depending on the strength of the partner network and the response of educators. As a result, the number of responses was not proportional to the size of the countries from which they were collected, with a total of 37% of responses coming from Poland and Turkey. This has important implications for the interpretation of the results, as the responses could have been driven by the specific educational and social environment present in the countries from which the most responses came. Firstly, the results showed that teachers are generally not well aware of the EU mission: A Soil Deal for Europe and that steps can be taken to increase awareness of the programme among educators in Europe.

Secondly, the results of the study provide an overview of the topics and the level of understanding that teachers teach them. This can help to understand which topics teachers consider important to teach in their classrooms. Based on this information, materials for teachers can be developed to promote knowledge of specific topics in the classroom. The results can also be used to identify for which topics teachers need additional teaching materials.

Thirdly, teachers' preferences for specific teaching materials can be used to develop specific materials and opportunities for educators to ensure that resources are used in the most efficient and effective way.

GT 16 - 707 - P

FROM APPLE PEEL TO COMPOST: VISUAL REPRESENTATION OF SOIL DECOMPOSITION UNDERSTANDING THROUGH STORYBOARDS

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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The "We Are Students Tackling Environmental WASTE" (OrgWASTE) citizen science project addresses soil quality stewardship through instruction on organic waste recycling. This study examines how secondary students' understanding of organic matter decomposition processes evolved through their participation in OrgWASTE, as revealed through visual storyboard analysis.

Data collection involved pre- and post-intervention storyboards from students in 6 secondary schools in Seville, Spain, who participated in organic waste recycling activities. Students created four-panel visual narratives depicting decomposition processes before and after the educational interventions. Based on the Grounded Theory, through the constant comparison method, researchers analyzed 78 pre-intervention and 67 post-intervention storyboards from 4th grade and 1st baccalaureate students (15-16 years), developing an emergent categorization system to evaluate their conceptual progression.

Storyboard analysis revealed significant shifts in students' mental models of decomposition. Before the intervention, 28.3% submitted incomplete storyboards showing minimal changes to initial organic matter (14.1%), fragmentation (3.9%), mere disappearance (6.4%), or rudimentary transformation (3.9%). Post-intervention, only 10.1% presented such incomplete narratives. The most notable advancement was in students' representation of decomposition outcomes. Post-intervention, 35.9% accurately depicted decomposition as generating valuable new material that benefits soil fertility and plant growth, compared to 23.1% in pre-assessments. The percentage identifying the product as "compost or manure" more than doubled (10.3% to 22.4%). Narrative development improved significantly, with only 7 students failing to use all storyboard panels post-intervention compared to 29 pre-intervention. Visual narratives showed evolving conceptual sophistication, moving beyond basic representations of color changes and size reduction (decreased from 20.5% to 17.9%) toward more complex depictions of material transformation. Interestingly, students with less advanced drawing skills often demonstrated more comprehensive conceptual understanding through their sequential narratives than peers with sophisticated artistic abilities, suggesting storyboarding as an effective assessment tool regardless of artistic capability.

Storyboard analysis demonstrates that participating in OrgWASTE enhances students' understanding of decomposition as a productive ecological process yielding valuable soil amendments rather than mere waste degradation. These findings highlight the potential of visual narrative assessment in environmental education (Babaian & Kumar, 2022) and the effectiveness of hands-on approaches in developing ecological literacy related to soil processes (Marchal-Gaillard, 2024).

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GT 16 - 718 - P

LOESS IN ACTION: GETTING SLOVAKIA TALKING, LEARNING, AND CARING ABOUT SOIL

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Soil degradation presents a significant threat to ecosystem services, food security, and climate resilience across Europe, with over 60% of soils classified as unhealthy. Addressing this complex challenge requires not only scientific and technological innovation but also a fundamental shift in public awareness and engagement with soil health. The LOESS project (Literacy boost through an Operational Educational Ecosystem of Societal actors on Soil health) addresses this need by advancing soil literacy through a transdisciplinary educational framework that mobilizes a wide range of societal actors.

This poster highlights the Slovak case study within LOESS, focusing on the co-creation of an operational educational ecosystem that integrates formal, non-formal, and informal learning environments. Using participatory methodologies, the project actively involves educators, students, researchers, policymakers, and local communities in the co-design of context-sensitive educational resources and activities. Grounded in a systemic approach, LOESS values both scientific and local knowledge, aiming to foster a deeper societal understanding of soil functions and the risks posed by soil degradation.

LOESS is funded under the EU Mission “A Soil Deal for Europe” within the Horizon Europe research and innovation programme (2023–2026). The Slovak implementation is further enriched by synergies with the national sister project, “Soil in the Mirror of Interdisciplinary Science,” supported by Slovakia’s National Recovery and Resilience Plan. This collaboration enhances LOESS through reflective, interdisciplinary perspectives that bridge science, education, and civic engagement.

Together, these initiatives contribute to the European Soil Mission by promoting inclusive, lifelong learning pathways that empower citizens to become active stewards of soil health.

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GT 16 - 884 - P

LITERACY BOOST THROUGH AN OPERATIONAL EDUCATIONAL ECOSYSTEM OF SOCIETAL ACTORS ON SOIL HEALTH

GT 16: SOIL LITERACY EDUCATION, & ART / GT 09. SOIL HEALTH

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Literacy boost through an Operational Educational Ecosystem of Societal actors on Soil health (LOESS) is a project that aims to map, connect and collaborate with multiple stakeholders grouped into Communities of Practice (CoPs) and Educational Innovation Groups (EIGs) across fifteen European countries. Its objective is to offer a comprehensive overview of the current level of knowledge related to soil health at different educational levels and to develop educational programmes and teaching materials that respond to the identified challenges and gaps.

The project is part of the EU Mission “A Soil Deal for Europe,” is coordinated by the science shop WILA Bonn, and brings together a consortium of 20 partners. It runs from 1 June 2023 to 31 May 2026.

A key milestone of the first project phase is the Report on Awareness, Needs and Vision for Soil Education, developed by Wageningen University & Research in collaboration with all LOESS partners [1]. This deliverable presents the current state and aspirations for soil education, identifying content deficits, educational needs, practical barriers, and enabling factors based on desk research, focus groups, interviews and questionnaires in the participating countries, and a survey across Europe. Among its main recommendations: at the macro level, to incorporate soil health topics aligned with the SDGs and the EU Soil Mission into curricula, and to reassess educational goals and assessment criteria to enable experiential and participatory learning; at the micro level, to improve teacher training with a focus on soil health and to develop new didactic materials using up-to-date content and outdoor, hands-on, and participatory methods.

In the second phase, LOESS has developed and tested various educational modules through co-creation with CoPs, EIGs and other relevant actors. These include: for schools – learning situations, a STEM teacher MOOC, and a blueprint of exemplary practices; for universities – a CERL/Science Shops methodology, a virtual module for lecturers, and student-led training modules. Cross-cutting tools include a glossary, crowdmapping tool, VR/AR application and field experiment demonstrations. All resources are integrated into the European Soil Education Atlas.

LOESS is currently in its third phase, focusing on dissemination and capacity building actions targeting schools, universities, policy makers and society at large. This poster presents the overall approach of the project, the evidence base provided by the report, and key actions underway.

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LOESS

LITERACY BOOST THROUGH AN OPERATIONAL EDUCATIONAL ECOSYSTEM OF SOCIETAL ACTORS ON SOIL HEALTH

LOESS logo



GT 16 - 903 - P

TRANSDISCIPLINARY SOIL LITERACY: REIMAGINING SCIENCE COMMUNICATION THROUGH INTERACTIVE STORYTELLING

GT 16: SOIL LITERACY EDUCATION, & ART / GT 16. CONNECTING PEOPLE AND SOILS

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Soils are foundational to sustainability, yet remain conceptually and emotionally distant from much of society. This disconnection stems partly from the inherent complexity of soil systems: they are dynamic biogeochemical entities, cultural archives, living environments, and material participants in human history. Soil science, accordingly, is an intrinsically multidisciplinary field, ranging from physicochemical modelling of pollutant fate to the sociocultural and economic dimensions of land use and stewardship. Enhancing soil literacy is a core challenge for European research, education, and policy, especially in light of the EU Soil Strategy and Soil Mission, which call for multidimensional understandings of human–soil relationships grounded in diverse worldviews, values, and knowledge systems. This work contributes to that aim by helping diverse publics engage with soils both scientifically and as cultural entities. To do so, we launched an interdisciplinary teaching collaboration titled Making the Invisible Visible between the Merz Akademie (University of Art, Design and Media) and the Zukunftskolleg (University of Konstanz). Together with five students, the team explored how virtual reality (VR) and interactive storytelling can be used to support soil science communication and education. Each student developed a unique VR experience addressing different aspects of soil systems and their entanglement with human and environmental narratives. One project presents soil profiles from contrasting landscapes (farm, desert, mountain, beach) and explore their links with soil properties. Another explores the erosion and preservation of a geoglyph to reflect on cultural heritage and its dependence on soil protection. A third shows an interactive soil museum, where visitors activate stories linking sculptures and landscapes. One gamified experience invites users to regenerate life in a desert by nurturing hidden seeds while confronting pollution. Another simulates the soil sampling process, offering an embodied view of scientific protocols. We explored the communicative and affective capacities of VR with a focus on spatial representation, information visualization, and interaction design, showing how interdisciplinary communication can build more inclusive, imaginative, and informed relationships with soil, by using VR as a tool of intimacy to connect people with the hidden layers of soils as physicochemical systems and bearers of memory, identity and cultural meaning. This collaboration therefore offers a prototype for science–arts engagement in support of EU soil literacy goals. We invite further dialogue with researchers, educators, and policymakers interested in shifting how societies value and care for soils through transdisciplinary experiences, interactive storytelling, and transformative soil education.

ACKNOWLEDGEMENTS

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GT 16 - 933 - P

SOILS OF THE PYRENEES: KNOWING THEM TO PROTECT THEM

GT 16: SOIL LITERACY EDUCATION, & ART / GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION

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The consequences of climate change directly affect the health and functions of soils. In the case of mountain areas, soils can be particularly sensitive to these consequences, because of their high vulnerability and increasing exposition to climate hazards. Indeed, mountain soils are generally poorly developed and very vulnerable (to erosion, compaction and loss of organic carbon, among others). In addition, the increase in temperature is responsible for a decrease in snow cover in the Pyrenees, which favors a greater exposure of soils to mountain uses. The question of the increase in pressure linked to the practice of various mountain sports and activities, in addition to the traditional uses of mountain areas, likely to permanently alter the functions of the soil, arises at present.

The SOLPYR project focuses on the vulnerability of mountain soils to climate change and on the consequences of mountain uses in this context of change in the Pyrenean range. The Pyrenean Soil Alliance carried out an initial identification of priorities for action and noted the need to act in three main areas: the unification of information on soils, the prevention of soil degradation and the raising of awareness of the population and mountain users of the issues surrounding soils. As such, the project aims to (i) provide unified information on mountain soils at the Pyrenees level as well as a catalogue of the main types of soils and their vulnerability, (ii) to define a series of good practices for the protection of mountain soils, and (iii) to create educational resources to raise the awareness of the population and mountain users about soil preservation, and to involve them through participatory science actions.

To this end, cross-border cooperation is essential for a better characterization of Pyrenean soils and their problems, as well as for better management and protection of the soils of the Pyrenees. The project proposes therefore to gather and unify transborder knowledge on soil characterization, soil degradation assessment, and soil education to increase our knowledge about the soils of the Pyrenes, and their conservation issues. Also, popular hiking trails will be used to develop soil-based itineraries as awareness-raising tools to involve users in the protection of the soil resource, by incorporating information and educational activities about soils. The various awareness-raising materials created will be shared with mountain refuges, Geoparks, parks, and nature reserves in the Pyrenees for their use and dissemination.

In addition, a protocol for the protection of the soil of the Pyrenees is planned for the regions and the competent public entities in each region. The SOLPYR project is based on the idea that a better knowledge of soils and the associated issues can raise the necessary awareness of mountain users and management bodies for the protection and conservation of this vital resource for the Pyrenees.

KEYWORDS

Mountain soils, public awareness, soil conservation, soil education and soil degradation.

GT 16 - 939 - P

ENCOURAGING AND SUPPORTING CURIOSITY IN OUR LIVING SOILS

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Natural England is the Government's statutory adviser on the natural environment established under the Natural Environment and Rural Communities Act 2006. Natural England's purpose is to ensure that the natural environment is conserved, enhanced, and managed for the benefit of present and future generations thereby contributing to sustainable development.

Natural England has been delivering a range of soil health focused projects in recent years. In addition to this essential scientific evidence and guidance, it was identified that the awareness of soils and their role in ecosystem function needs to be encouraged from a young age.

"Our Living Soils" was commissioned by Natural England to explore soil health in a way that appeals to four to seven-year-old children (Figure 1). The illustrated book highlights just how much is going on in our soil and focuses on the creatures that make it their home. It was written by author and schoolteacher Emma Rosen, and illustrated by fine artist and illustrator, Rhiannon Thomas.

The book was launched during the Open Farm Sunday event at Springwater Farm in Exeter, UK. The team hosted a series of activities including round the campfire storytelling; soil minibeast drawing and writing activities; and the very popular exploration of soil dwelling organisms through the microscope.

From soil formation to soil function, this visually engaging book aims to raise the awareness of soils to young children and their parents alike. We hope it engages young children and develops their curiosity about the fascinating, but hidden, world beneath their feet.

This poster explores the process of preparing a scientifically accurate, yet engaging book, and the subsequent engagement with members of the public.

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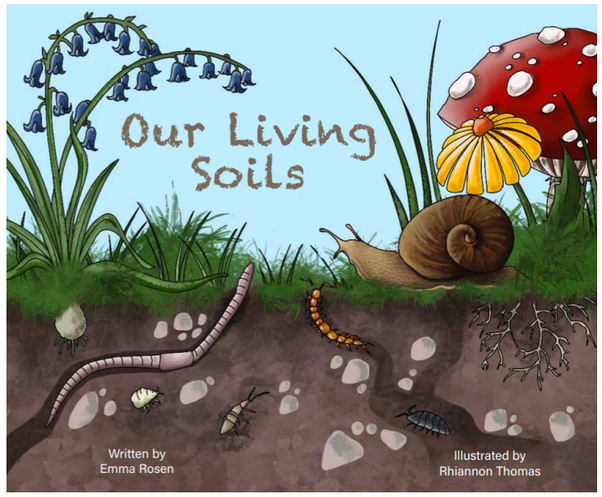


Figure 1: Our Living Soils Front Cover



GT 16 - 988 - P

BONEQUINHAS DA TERRA: FAMÍLIA PEDON, MATERIAIS DIDÁTICOS SENSORIAIS PARA A DISSEMINAÇÃO DA EDUCAÇÃO EM SOLOS NO BRASIL.

GT 16: SOIL LITERACY EDUCATION, & ART / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Soil education in Brazil, or the possibility of educating on this topic, advanced significantly with the establishment of the “International Year of Soil” by the UN/FAO in 2015. The objectives established for this event fostered actions that aligned soil use and conservation practices with the sustainability of this natural resource in mind. Therefore, education could not be left out, as it is included in the fourth SDG (Sustainable Development Goals), aiming for quality education and will always be the path to advancing critical and creative thinking in making tangible initiatives and decisions to achieve the global goals of achieving healthier and more preserved soil. With this in mind, the “Pedon Family” was created, born from the need to disseminate soil education—a topic previously hidden in school subjects but now requiring emphatic explanation, thus ensuring the perpetuity of this resource, as well as its quality for future generations. This family is composed of 08 dolls created from the Artificial Intelligence (AI) of Imagem Creator, where each one has characteristics of a class of soils existing in Brazil, the characteristics and personification of each doll were obtained from pedological works such as: Santos (2025), Lepsch (2021) and Teixeira (2019) Among the soils represented, there are: LATOSOLS, ARGISOLS, PLINTOSOLS and NEOSSOLS, soils with greater geographical representation of the territory and ORGANOSOLS, CHERNOSOLS, SPODOSOLS, these being of smaller geospatial distribution. The names of the members of this family reveal which soil classes they correspond to, as well as: Argis, Petra, Plintita and Petrus, Chernon, Latis, Organo, Bebe Neo, Arty. Since its inception as a teaching-pedagogical project in 2024, the project has been carried out on an itinerant basis both inside and outside the UNESP Jaboticabal/SP campus. The “Boquinhas da Terra” (Little Earth Dolls) introduces its family. The Pedon family has served Jaboticabal and three municipalities: Pindorama, Monte Alto, and Matão, offering soil painting workshops, soil-based decorative object construction, and lectures on the importance of soil and conservation measures. These activities help develop students’ curiosity and critical thinking about the importance of this resource. For administrators and teachers, it provides another educational opportunity. To date, 350 students and educators from the municipal school system have been met. Given the above, the use of the Pedon family as sensory teaching material fulfills its objectives of contributing to the dissemination of soil education in Brazil.

ACKNOWLEDGEMENTS

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Família Pedon

GT 16 - 1111 - P

DIGGING FOR ANTIBIOTICS: EDUCATING FOR ONE HEALTH FROM SOIL

GT 16: SOIL LITERACY EDUCATION, & ART / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Soil health should be a central focus for One Health framework, as it directly impacts human, animal, and environmental well-being. Soils harbor vast microbial biodiversity, including natural antibiotic producers, and serve as reservoirs of resistance genes that can potentially spread to humans and animals. Moreover, soil conditions affect water and food quality, indirectly impacting overall health. Despite its importance, soil health is largely overlooked in public health, veterinary, and medical education and policy frameworks [1].

Inspired by Tiny Earth international network, MicroMundo project in Spain and Portugal follows a service-learning strategy to train students on One Health multidisciplinary concepts, particularly focusing on antimicrobial resistance [2]. Following a crowdsourced citizen science model, MicroMundo engages university and high school students in isolating soil microorganisms with potential antibiotic properties. During the last editions, the hub based in Toledo (Spain), MicroMundo@UCLM, introduced new activities to characterize the soil properties of samples used in antibiosis assays and the ecosystems from which they originate. Additionally, an online form was developed in which high school students submitted their results. The collected data includes: (i) information about the soil sampling area (coordinates, vegetation, lithology, climate, etc.); (ii) basic soil variables (pH, texture, organic matter and soil water repellency); and (iii) results of the antibiosis assays against Escherichia coli (Gram negative) and Staphylococcus aureus (Gram positive).

Over the past three years, we have analyzed these datasets to explore potential correlations between soil/ecosystem types and the presence of antimicrobial activity in microbial isolates.

Beyond the isolation of microbial strains showing antibiotic bioactivities, this collective effort boosts wakefulness on One Health-oriented scientific careers in various educational levels, highlight the value of interdisciplinary science, and inspire our future researchers into solutions to this current global health challenge based in the protection of soil biodiversity.

ACKNOWLEDGEMENTS

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GT 17.
SOILS AT THE CROSSROADS SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE

Communication formats

- ORAL COMMUNICATIONS
- FLASH+POSTER
- POSTER

GT 17 - 54 - O

THE ROLE OF CITIZEN SCIENCE IN CONNECTING PEOPLE WITH SOIL: A CASE STUDY FROM VOJVODINA, NORTHERN SERBIA

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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Healthy soil plays a key role in food production and quality, directly impacting human health. However, comprehensive soil health monitoring remains a significant challenge in Serbia and globally. The two-year citizen science project, Soil Health Guards (https://eu-citizen.science/project/525) aims to complement existing research by deepening the understanding of soil health and facilitating collaboration among farmers and youth as citizen scientists, local civil organizations, and research institutions. Farmers and youth as citizen scientists have been recruited through multi-channel outreach, combining partnerships with local civil agriculture organizations, alongside media and diverse digital communication platforms, to monitor key soil health indicators in Vojvodina, Serbia throughout 2024-2025. Indicators were selected based on pre-defined criteria (scientific significance, sensitivity to farm management and ease of measurement) and informed by insights from agricultural organizations, ensuring that they reflected the specific needs and challenges of local farmers. The finally selected soil health indicators included organic matter decomposition, earthworm biodiversity, pH/NPK status, soil structure, texture, and bulk density. Participants received toolkits and training needed to successfully conduct and communicate the measurements performed on their parcels to the researchers. For citizen scientists, data analysis was facilitated using a simple, color-coded traffic light system for interpreting results (green – good; yellow – caution; red – poor). The citizen science results will be further validated through a selected set of referent laboratory protocols and analysis of soil structure, density, texture, pH, and organic matter content. Additionally, the final stage of the project will include metagenomic analysis of the soil microbial communities in selected set of soil samples. Data gathered from 70 active participants across 17 reported soil types, revealed notable variability in soil health indicators. Earthworm counts showed seasonal differences, with autumn counts generally higher than spring. Decomposition analysis reflected diverse microbial activity levels. Soil texture assessment and bulk density measurements also highlighted soil structure variations, ranging from organic-rich soils to compacted layers. Finally, pH ranged from strongly acidic (pH 4) to moderately/strongly alkaline (pH 9). In conclusion, the citizen science approach, combined with standardized methods and data validation, holds the potential to enhance soil health monitoring and promote sustainable agricultural practices.

ACKNOWLEDGEMENTS

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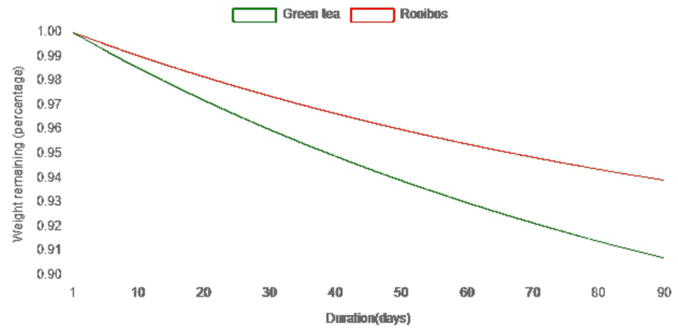


Fig 1. Results of red and green tea bag decoposition over 90-day period for toolkit ID 5

GT 17 - 71 - O

THE ROLE OF EU SOIL DEAL FOR EUROPE MISSION AND SOILS4MED PROJECT TO PROMOTE SOIL HEALTH

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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There is a very good synergy between the EU Mission Soil Deal for Europe and the SOILS4MED project funded by the PRIMA Initiative. The Soil Mission has put forward the target to establish 100 Living Labs and Lighthouses around Europe, while SOILS4MED will establish Living Labs (LL) in 9 countries, among them 6 located in North Africa and the Middle East. The Soil Mission targets intend to reduce the trends of soil degradation in Europe that is causing damages calculated at 50 billion € per year as still 60-70% of the soils are unhealthy and millions of contaminated sites are spread throughout the continent, while soil erosion and desertification are affecting soil health and the livelihoods of the many people, mostly those located in the Southern Europe. Nevertheless, the situation in North Africa and the Middle East is by far worst due to pedo-climatic conditions, socio-economic and political conditions all aggravated by climate change and SOILS4MED has a major role to play in that area, considering that the project LLs aim at co-designing integrated soil health monitoring and information systems tailored to Mediterranean soils and environments conditions.

The SOILS4MED approach is scientifically based and pragmatically oriented towards problem solving. It is inspired by the Soil Mission objectives to fund ambitious research and innovation programme with a strong social science component and to develop a harmonised framework for soil monitoring in the Mediterranean by raising awareness of people for the vital importance of soils. The SOILS4MED project place particular emphasis on the establishment of a Soil Data and Information (SDI) system that will act as catalyser to develop policy relevant integrated indicators and monitoring protocols adapted to the environmental conditions and needs of the Mediterranean Region. Much of the strength of the project comes from the work being done in all the Living Labs as the bases for developing strategies that represent the major agro-ecological regions and soil types, with the ardent goal of developing a harmonized SDI to monitor soil health throughout the region based on country level soil data.

Project bring together 15 partners from 9 Mediterranean countries representing academia and governmental institutions. The partnership is enriched by long term academic professionals and young researchers with great ambitions to embark in soil research. It has been instrumental so far to be present in several events of particular importance such as the Centennial event of the IUSS held in Florence in 2024, GSP at FAO headquarters in Rome in 2024, COP16 of UNCCD in Riyadh Saudi Arabia in December 2024 and in many more local and regional events. Finally, in close collaboration with the JRC Ispra in Italy of the SOILS4MED will assist the establishment of the Soil Atlas of the Mediterranean as a first landmark publication to represent the soils of three continents (Europe, Africa and Asia) all in one single document.



GT 17 - 126 - O

INTEGRATED LANDSCAPE APPROACH TO AGROECOSYSTEM MANAGEMENT FOR HARMONISING THE USE OF GEOECOLOGICAL AND AGROECOLOGICAL POTENTIAL: INSIGHTS FROM A LITHUANIAN CASE STUDY

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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In the context of today's pressing ecological challenges, the development of agroecosystems must align with the principles of sustainable development. This is important in order to ensure the sustainable long-term use of soil, the preservation of soil organic carbon (SOC) stocks, the reduction of soil erosion risk, and the maintenance of biodiversity within it. Agroecosystems are understood as dynamic territorial systems that integrate agricultural land use (crops, pastures, livestock), drainage infrastructure, and natural environmental elements. Their functioning is maintained through the interaction of biotic and abiotic components, supported by agrotechnical and agrochemical interventions [1]. However, the term agroecosystem remains variably defined, leading to methodological and practical inconsistencies across different scientific disciplines and sectors of human land use.

From a geographical perspective, agroecosystems can be seen as managed systems of land and natural resources, designed primarily to meet human food needs and to provide other beneficial outputs [2]. A sustainable agroecosystem is characterised by its ability to conserve soil and other natural resources, protect the environment, and improve livelihoods while remaining economically viable and socially inclusive [3]. This multidimensional understanding of sustainability forms the foundation for integrated approaches to agroecosystem development.

This presentation introduces an integrated territorial-landscape planning approach for agroecosystem development, that incorporates the principle of ecological sensitivity, the natural framework (ecological network) principle, and landscape structural complexity, aiming to balance geoecological and agroecological potential. Key components include the assessment of natural landscape structure, soil and water potential, ecological resilience, and anthropogenic (agricultural) pressures. The principle of the natural framework is presented as a fundamental basis for spatially differentiating the use of agroecosystem resources, with particular emphasis on soil and the intensity of economic activities.

This study examines representative case study areas within the territory of Lithuania, selected for their diverse geoecological conditions. By identifying spatial patterns, ecological sensitivities, and functional limitations and intensity of agroecosystems and soil use, the study aims to contribute to transdisciplinary soil science by linking geography, ecology, and land-use planning, and by providing practical recommendations for sustainable agricultural and territorial policy.

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GT 17 - 203 - O

SUSTAINABILITY INCENTIVES IN CERTIFIED SEED PRODUCTION: LINKING SOIL HEALTH, MARKET SIGNALS, AND FARMER BEHAVIOR

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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Sustainable seed systems are essential to advancing climate-smart agriculture by maintaining soil health, supporting biodiversity, and mitigating climate change. Environmentally friendly seed production practices such as minimized soil disturbance, cover cropping, and the use of improved seed varieties can enhance sustainability and reduce carbon losses. However, the social and economic dimensions—particularly the willingness of farmers and consumers to pay more for sustainably produced seeds—remain underexplored. Despite increasing environmental awareness and policy momentum from initiatives such as the European Green Deal, the EU Soil Strategy, and the Soil Monitoring and Resilience Directive, the seed sector's market dynamics and sustainability incentives are not yet well understood. Integrating sustainability into seed production may offer both ecological benefits and long-term competitive advantages.

The Seed Centre of the Estonian Centre of Rural Research and Knowledge (METK), as a key state-owned producer of certified seed, reflects the prevailing practices in the sector, including conventional tillage and chemical inputs. Its operations serve as a valuable case for examining both current methodologies and the potential shift toward soil-health-oriented seed production.

As part of the NOVASOIL project (Innovative Business Models for Soil Health), we explored whether a business model supporting soil health through seed production is feasible in Estonia. A survey conducted among Estonian farmers in late 2024 investigated their willingness to pay a premium for carbon-labeled seeds. Logistic regression models, based on 122–169 valid responses, were used to assess influencing factors.

Results show that farmers participating in carbon programs and those prioritizing sustainability were significantly more likely to pay more for carbon-labeled seeds—especially when market advantages were perceived. Farmers who valued certified seed for sowing efficiency also expressed higher willingness to pay. In contrast, respondents opposing environmentally linked subsidies or using conventional plough-based tillage methods were less supportive. Socio-economic factors such as higher income and tertiary education were positively associated with willingness to pay, while male respondents were less inclined to accept higher costs. Additional positive drivers included valuing soil health, support for greenhouse gas labeling, and a preference for environmentally labeled products.

These findings indicate that environmental attitudes, farming practices, and economic incentives are key factors shaping sustainable seed purchasing behavior. Policy interventions should focus on encouraging participation in carbon programs and linking subsidies to sustainable practices. Further research is needed to evaluate the long-term effects of carbon labeling and to identify barriers among conventional tillage users.

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GT 17 - 205 - O

EFFECT OF ABANDONED RURAL SETTLEMENTS RESTORATION ON ECOSYSTEM SERVICES: TOWARDS A SUSTAINABLE ECOLOGICAL TRANSITION IN RURAL AREAS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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The accelerating depopulation of rural Spain, particularly in mountainous regions, has led to vast areas being designated as part of the so-called “España vaciada” (“emptied Spain”). This phenomenon poses a significant socio-environmental challenge that demands urgent scientific attention. Rural mountain areas are critical for sustainable development, as they deliver a wide array of ecosystem services (ES). We investigated the potential of rural repopulation and settlement restoration as a strategy to counteract depopulation and enhance ecosystem service provision in the project RENURSE. Adopting the ecosystem services framework, this study compares the ES provided in the surroundings of abandoned villages with those of adjacent settlements that have undergone repopulation and restoration in the last 30–40 years. Research is being conducted across three case study areas characterized by extremely low population densities (<4 inhabitants/km²), located in the Central System and the Pyrenees—two of the most depopulated mountainous areas in Spain and Europe.

The central hypothesis of this study is that restoring abandoned settlements not only contributes to population stabilization but also improves environmental and social sustainability in depopulated mountain regions. The specific objectives are: (1) to evaluate the impacts of abandonment and restoration on land use and cover, and (2) to assess their effects on the provision of key ecosystem services. By assessing different land management scenarios—continued abandonment, maintenance, and active restoration—we aimed at identifying the most productive, sustainable, and socially viable models of territorial use.

To achieve this, we employed different mixed-methods approach that applies field-based data collection (e.g., soil and vegetation analysis, biodiversity surveys) with geospatial data analysis, database explorations, literature review and surveys to local population. The ecosystem services evaluated include: soil quality regulation, soil fertility, climate regulation (carbon sequestration and storage), water production and quality, agricultural and livestock productivity, species and habitat biodiversity (flora and avifauna), regulation of extreme events, and the cultural value of mountain landscapes. Our results are intended to inform evidence-based policy and land-use planning strategies that promote both ecological and demographic revitalization of Europe’s mountain regions.

ACKNOWLEDGEMENTS

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Drawing of an abandoned village in northern Aragón.
(C) Drawing by F. Villaespesa.

GT 17 - 220 - O

QUANTIFYING SPATIAL UNCERTAINTY TO IMPROVE THE PREDICTION OF SOIL PROPERTIES IN DATA-SPARSE REGIONS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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Artificial Neural Networks (ANNs) are valuable tools for predicting soil properties using large datasets. However, a common challenge in soil sciences is the uneven distribution of soil samples, which often results from past sampling projects that heavily sample certain areas while leaving similar yet geographically distant regions under-sampled. One potential solution to this problem is to transfer a pretrained model to other similar regions. Robust spatial uncertainty quantification is crucial for this purpose, yet often overlooked in current research.

We address this issue by using a Bayesian deep learning technique, Laplace Approximations, to quantify spatial uncertainty. This produces a probability measure encoding where the model’s prediction is deemed reliable, and where a lack of data leads to overwhelming empirical uncertainty. We train such an ANN on a soil landscape dataset from a specific region in southern Germany and then transfer the trained model to another part of the same landscape, as well as to a new, unseen region, without any further model training.

Quantifying empirical uncertainty in this way allows stakeholders to better identify regions and settings in need of further targeted data collection, enhancing decision-making and prioritizing efforts in data collection. Our approach is computationally lightweight and can be added post-hoc to existing deep learning solutions for soil prediction, thus offering a practical tool to improve soil property predictions in under-sampled areas, as well as optimizing future sampling strategies, ensuring resources are allocated efficiently for maximum data coverage and accuracy.

ACKNOWLEDGEMENTS

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GT 17 - 340 - O

LAND COVER CLASSIFICATION EFFECT ON SOIL MONITORING: A COMPARATIVE ANALYSIS OF LUCAS AND SWEDISH NATIONAL INVENTORY ON AGRICULTURAL SOILS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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National soil monitoring systems and the Land Use/Land Cover Area Frame Survey (LUCAS) at European level exist in parallel. Both repeatedly sample and analyze soil properties to evaluate major changes over time, supporting national and EU polices on monitoring soil health including soil organic carbon (SOC). However, the comparability of the two systems is still disputable. Identifying sources of discrepancies will help to harmonize different monitoring datasets and to obtain consistent estimates for spatiotemporal changes. In this study, we compared SOC changes in 0-20 cm topsoil of cropland and grassland using LUCAS in 2009, 2015 and 2018 with two Swedish national crop and soil inventories. Further, we overlaid the LUCAS land cover classes with Swedish agricultural block and spatial parcel databases in 2015 and 2018 to evaluate the effect of land cover classification on monitoring SOC changes in agricultural soils. Revisiting sampling points from LUCAS, the median annual SOC change (ΔSOC; g C kg-1 year-1) between 2009 and 2018 was slightly negative (-0.03, 95% confidence interval -0.17-0.12) for cropland and positive (0.34, -0.02-0.77) for grassland. In contrast, the Swedish national crop and soil inventory showed an increase in ΔSOC (0.07, 0.06-0.10) for cropland based on 1678 revisited points, and a decrease (-0.31, -0.95-0.05) for grassland based on 55 points. Overlying the LUCAS grassland points with the Swedish block and parcel database, we found that about 80% of the extracted points belonged to cropland in the Swedish system, and nearly 90% of this inconsistency was attributed to leys and different categories of fallow. Comparing ΔSOC from LUCAS between 2015 and 2018, assigning misclassified ley and fallow points to cropland shifted the distribution of ΔSOC to higher increment for the cropland. Despite the rotational ley being considered as temporary grassland under the cropland category according to LUCAS technical classification, we found that Swedish leys and fallow were often recorded as grassland within the LUCAS survey. Almost half of the Swedish cropland consisted of forage crops which are grown in rotation with annual crops. Thus, predicting ΔSOC based on the land cover change from LUCAS can lead to severely biased estimations, e.g. [1] reported SOC declines in cropland soils in Sweden. In conclusion, it is important to recognize differences in cropping systems and to consider the more precise information on land cover classification that is available on national scale in several Member States. There is a need for better data integration and harmonization of the comprehensive datasets available at national and European scales.

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GT 17 - 378 - O

EMPOWERING STAKEHOLDERS TO DRIVE FARMING SYSTEM TRANSITION: CONVERSATIONS ON AGROECOLOGY

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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AGROECOLOGY, the European Partnership “Accelerating Farming Systems Transition: Agroecology Living Labs and Research Infrastructures,” is a significant European research and innovation initiative involving the European Commission and 26 Member States, Associated Countries, and Third Countries, with a total of 72 partner organizations. The goal of AGROECOLOGY is to assist the agricultural sector in addressing the challenges of climate change, biodiversity loss, food security and sovereignty, and environmental sustainability, while ensuring agriculture remains profitable, sustainable, and attractive to farmers.

Transforming the agricultural sector to meet societal and policy demands requires bold and systemic changes. AGROECOLOGY fosters for solutions that leverage natural and biological processes, blending state-of-the-art science, technology, and innovation with farmers’ knowledge. By pooling resources from the European Commission and the involved member states and regions, the Partnership funds high-level research in Living Labs and Research Infrastructures, co-creating relevant knowledge and technologies aligned with the priorities of the Strategic Research and Innovation Agenda for the Farming System Transition.

To support these efforts, a range of activities is being implemented to inform, engage, and empower stakeholders. These activities aim to enhance capacities, raise awareness, and facilitate the exchange of knowledge and data. A key element of this effort is the Conversations on Agroecology which serve as foundational steps to strengthen agricultural knowledge and innovation systems (AKIS) for agroecology. These conversations foster collaboration and connections between Living Labs, Research Infrastructures and stakeholders across Europe.

The online Conversations on Agroecology are held monthly throughout the Partnership, enabling the mobilization and networking of agroecology actors in Europe and beyond. In 2024, six online conversations were organized on various themes, such as the role of AKIS for agroecology, agroecological transition, and the power of networks for agroecology. Through these monthly conversations, AGROECOLOGY engages diverse groups of actors, ensuring involvement of institutional AKIS actors, farmers, and farming networks to ensure inclusive participation and drive progress toward sustainable food systems by 2030.



GT 17 - 386 - O

UNVEILING PLURAL VALUES IN SOIL MANAGEMENT: A CASE STUDY FROM THE MONTADO AGRO-SILVO-PASTORAL SYSTEM IN PORTUGAL.

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Farmers' and landowners' decisions affecting soil management reflect not only economic motivations related to productivity, but also deeper principles and values associated with soil health. However, such values are often implicit and not explicitly acknowledged in decision-making processes. In complex agro-silvo-pastoral systems like the Montado in Southern Iberia, where multiple productive and climatic pressures intersect, soil often remains hidden in farmers' strategic priorities. This study investigates the values and motivations behind soil regeneration efforts in the Montado, a multifunctional system capable of delivering a wide range of ecosystem services but increasingly threatened by degradation and decline. Drawing on interviews with farmers and landowners, we developed a value-based understanding of soil health through the analytical dimensions of care, knowledge, and agency. While Montado farmers show strong commitment to soil health and have sought out education and innovative practices, they often lack long-term planning capacity, technical support, and feel poorly supported by current policy instruments. This results in fragmented and short-term soil management strategies. At the same time, key relational values including place attachment, self-determination and stewardship, emerge as powerful motivators for regenerative practices. Yet these values alone are not sufficient to translate into effective agency when the agricultural knowledge and innovation system (AKIS) remains weak and uncoordinated. The case of Montado underscores the need for governance frameworks that recognize both instrumental and relational values, integrating them into policy and advisory systems. Doing so could better align support structures with farmers' lived realities, enabling more coherent and scalable soil regeneration efforts.

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GT 17 - 503 - O

TRACKING SOIL PROPERTIES CHANGES FROM LEGACY SURVEY TO MODERN MONITORING SYSTEMS THROUGH SPATIAL ANALYSIS – CASE OF WALLONIA, SOUTHERN BELGIUM

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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Between 1949 and 1965 in Belgium, the National Soil Survey (NSS) resulted in the description and analysis of about 13,000 soil profiles to create the Belgian soil map [1]. The resulting legacy database ("Aardewerk" [2]) contains precious information per horizon (up to a depth of about 1.5 m) for each soil profile, e.g., texture, SOC content, pH and rock fragment content (RF). Other information such as "soil series", land use, and coordinates of the profile, is also available. From this national database and map, the detailed Digital Soil Map of Wallonia was created.

Since then, different monitoring systems including soil analysis have been developed for diverse land uses and purposes in Wallonia. In parallel, many spatial layers (raster and vector) have been created at the Walloon scale covering environmental parameters controlling soil development and evolution, as climatic, topographic and land cover parameters (see the SCORPAN theory [3]).

Today, considering the Walloon Recovery Plan, the European Soil Strategy and the future Soil Monitoring Law, legacy and modern soil data are gathered in a historical database, analyzed and compared through their temporal and spatial patterns. Different methods - including non-parametric statistics, Machine Learning methods and Digital Soil Mapping - are used to better understand the evolution of Walloon soils over the last decades and to identify the main environmental parameters responsible for. To finish, the spatial models developed through the above spatial analysis process are used as major input information in the design protocol of the new Walloon Soil Monitoring (WSM) system (following the Soil Monitoring Law requirements).

We will talk about the data analysis process, how the different data sources and methods are considered, nested and compared (including the uncertainties). The first results of the spatio-temporal analysis will be provided, and we will consider the near future through the ongoing development of the Walloon Soil Monitoring system.

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GT 17 - 545 - O

MODIFYING SOILS AND CULTURE AS A RESPONSE TO DYING CHILDREN AND EXTREME WEATHER CONDITIONS BY THE WAYUU INDIGENOUS COMMUNITY IN COLOMBIA

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Colombia is one of the most vulnerable countries to climate change, and the Wayuu Indigenous Community, located in the northern part of the Country, in La Guajira State, is aware of this. The state has temperatures between 35 and 40 °C. It has a decrease of 60% in rainfall. In addition, it has strong winds, which cause soil degradation due to erosion in 73% and salinization in 47%, loss of organic matter, and the predominance of desert ecosystems. Its % of unmet basic needs are 58%, and its food insecurity rate is 59.1%, highlighting with scarcity of food production necessary for self-consumption and local supply. This state is the highest one with reports of morbidity cases and there are still children who die from malnutrition. The economy is supported by goat livestock; they are nomads who look for pasture areas and water. There were several challenges: access to water, fertile soil (it was mainly sand), and overcoming the climatic barriers. The change started by the donation of a school to the Community in 2013 by The Maria Luisa de Moreno International Foundation, an ONG. This ONG looked for ways to produce food, and they considered that the goat fecal material was abundant after generations of pastors in the community, so it can be compostable. They started to do experiments and found that after 15-20 days under extreme weather conditions, the compost was done. So, they mixed the local soil with goat compost obtaining good results. In addition, they learnt about efficient water use. Women took a leadership never seen before, because they were considering objects by men. They started planting trees, such as acacia, mahogany, ceiba, and others. The trees generated windbreaks, helped to harvest water, and gave shade, decreasing temperatures of up to 5 degrees (the process took 4 years). To plant the crops and make them prosper, they thought in an ecosystem way, saving water and sharing it among the families, the animals, and now the plants, and planting fruit trees and tubers, in an organic and rotational system for self-consumption. Some of the products planted were Yucca, Papaya, Watermelon, Plantain, Eggplant, and grass for the goats. All in a local, diverse, and 100% sustainable system, without chemicals and with visible soil recovery and increase resilience and biodiversity in the area. In the project, climate conditions were measured, as well as water and soil quality. In addition, productivity efficiency and social indicators were calculated. Children began to gain weight and overcome malnutrition. Biodiversity increased, some mammals such as rabbits and foxes are returned as birds, iguanas, and insects as butterflies, showing beneficial activities. Weather conditions showed microclimate benefits and soil quality was highly improved. Water from the river needs treatment, but the water from the wells is good for productive conditions. Women are leaders now and they are rotating crops to preserve the soil.

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GT 17 - 574 - O

GRANADA TIERRA VIVA: MAPPING SOIL ISSUES IN SOUTHWEST EUROPE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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Granada Tierra Viva is a Living Lab developed within the framework of the European SOILCRATES project, focusing on territory and soil in the province of Granada (S Spain). This innovation ecosystem integrates multidisciplinary efforts to promote sustainability, the circular economy, and environmental resilience, focusing on soil preservation and restoration, consolidating itself as a pioneering model of territorial collaboration. This study aims to identify critical soil health challenges in Granada, using an innovative quadruple helix approach that unites insights from scientists, local stakeholders, industry, and government entities. Given the widespread issues affecting soils in this area—including structural degradation, biodiversity loss, and reduced agricultural productivity—our project seeks a comprehensive understanding of these localized challenges to develop sustainable solutions. The first step of this work will conduct surveys with key stakeholders who rely on soil for their activities, including farmers and cooperatives in the Granada region. These surveys will aim to identify and understand the specific soil health challenges they face, such as soil degradation and nutrient loss. Additionally, we will gather information to understand basic aspects that will inform the design and implementation of effective strategies for improving soil health. By collecting this data, we aim to develop sustainable solutions tailored to local needs and enhance collaboration among the various actors involved in soil management. This will be supported by pilot projects developed on soils cultivated with representative crops in the region, such as olive groves, fruit trees, cereals and vegetables. Findings from this study will directly contribute to the goals of SOILCRATES by supporting the development of science-backed, sustainable management strategies that address the specific needs of this region. Our approach will empower stakeholders in Granada with actionable, innovative solutions to mitigate soil degradation and protect the agricultural resources aligns with the EU Mission ‘A Soil Deal for Europe’.

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GT 17 - 594 - O

THE LILAS4SOILS PROJECT: CARBON FARMING IN THE MEDITERRANEAN REGION

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The LILAS4SOILS project, funded under the EU Horizon Europe “A Soil Deal for Europe” Mission, is a pioneering initiative aimed at transforming soil management and promoting sustainable agricultural practices across the Mediterranean and Southern European regions. The project has established five Living Labs (LLs) in six countries, bringing together more than 80 farmers, 125 stakeholders, and 24 expert partners to co-create, co-implement, and co-monitor different carbon farming practices across 85–100 demonstration sites. The project’s core focus is on fostering climate adaptation and mitigation through enhancing soil health, with particular emphasis on peatland management, agroforestry, livestock and manure management, nutrient management, and the maintenance of soil organic carbon (SOC). Among these LLs, IBERSOILL is the only transnational Living Lab, located in the cross-border regions of Portugal and Spain. Co-led by Food4Sustainability (PT) and the Instituto Tecnológico Agrario de Castilla y León (ES), with the support of partners such as INIAV (PT), URCACyL (ES), and EIT Food South (ES), IBERSOILL implements a collaborative, multi-actor approach that integrates farmers, academia, industry, policymakers, and civil society. Its launch event, held on 25 February 2025 in Ciudad Rodrigo, Spain, marked the beginning of a participatory process where stakeholders actively contribute to defining the mission, vision, and objectives of the LL, as well as providing feedback on proposed carbon farming practices. The IBERSOILL structure, like other LLs, enables real-life experimentation, continuous monitoring, and robust assessment of environmental and economic impacts, underpinned by standardized Monitoring, Reporting, and Verification (MRV) frameworks for soil health and SOC. By fostering cross-border collaboration and knowledge exchange, IBERSOILL not only addresses the pressing challenges of soil degradation and desertification in the Iberian Peninsula but also serves as a model for scalable, stakeholder-driven innovation in soil management. The outcomes of IBERSOILL are expected to inform policy, support the development of sustainable business models for carbon farming, and contribute to the long-term resilience and productivity of European agricultural soils.

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GT 17 - 679 - O

MICROPLASTICS IN SOIL AND BIOSOLID SAMPLES: QUANTITATIVE ASSESSMENT WITH A NIR SPECTROSCOPY MULTIVARIATE APPROACH

GT 11. SOIL DEGRADATION, DESERTIFICATION, CONTAMINATION - CONSERVATION, MITIGATION, REMEDIATION / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Given the extensive research and assessment of microplastic pollution in marine environments, recent years have seen a growing shift with focus toward terrestrial ecosystems, which are now considered potentially to have greater storage of microplastic accumulation compared to aquatic systems. Industrial activities are regarded as the primary sources of microplastic pollution in soils. However, agricultural activities also contribute significantly through the use of plastic mulching films, irrigation pipes, greenhouses, compost and organic soil amendments for fertilization.

From a methodological point of view, there is currently no standardized procedure for quantifying microplastic contamination in complex matrices such as soil. Moreover, the presence of organic matter within soils further complicates the extraction of microplastics, necessitating a preliminary oxidation step. The use of spectroscopic techniques, in combination with multivariate analysis, may offer a faster and more cost-effective approach for assessing microplastic pollution.

This study evaluates the capacity of Near-Infrared (NIR) spectroscopy to quantify the presence of synthetic polymers in matrices with different organic matter contents. The presence of various concentrations of polymers, artificially added, was assessed using spectroscopic techniques coupled with multivariate analysis of spectra pre-processing and regression, starting from sandy soil samples (low in organic matter) and biosolid samples (rich in organic matter and a byproduct from wastewater treatment). Preliminary results indicate that NIR spectroscopy is capable of distinguishing different synthetic polymers from the background matrix, although variations in organic matter content influence the predictive performance of multivariate regression models. This approach could facilitate the more efficient and rapid identification and quantification of microplastics, enabling the detection of pollution hotspots and the formulation of targeted remediation strategies.

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GT 17 - 734 - O

MULTIDISCIPLINARY APPROACH TOWARD SOIL STUDIES: CHALLENGES AND ACHIEVEMENTS FROM ARMENIA

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Soil, acting as a “mirror” of both natural and anthropogenic landscapes, reflects, records and even responds dynamically to environmental, economic, social and political changes. At the same time soils plays a crucial role in the security and resilience of different ecosystems including and socio-systems. This multifunctionality of soils requires integrative and multidisciplinary approaches to address complex soil-related challenges. Scientifically approved methods which bridge environmental science, food security, human health and SDGs are fundamentals in this regard. It should be inclusive enough to bring together different groups in society, applying quadruple helix approach. The Center for Ecological-Noosphere Studies (CENS, www.cens.am) advances this mission by conducting interdisciplinary and transdisciplinary research focused on ecosystem functionality, agricultural and urban resilience, environmental monitoring, sustainable resource use, food system sustainability and health, and simultaneously is trying to engage governmental bodies, Universities, students, civic society.

CENS combine data from different departments and disciplines, thus strengthening its problem oriented multi - disciplinary research capacities. This fact is making CENS as a leading regional organization in the field of soil research. Data generated during several decades and research outcomes can be used for different purposes including evidence-based decision making covering broad spectrum of soil related issues: from land use to integrated human health risk.

This review case study is demonstrating a multidisciplinary approach to soil research via utilizing methods such as multi-sensor remote sensing, geochemical surveys, environmental and health risk assessment, including food-related risk and benefit assessment and ecological modeling. During decades a soil archive was established preserving samples from local and regional scale soil studies. CENS contributes directly to the achievement of multiple SDGs including soil related ones. Further scientific findings are widely disseminated through various educational levels and platforms including the UNESCO Chair, master’s and PhD programs, youth scientific schools, micro-credentials, and the GLOBE program, all coordinated by CENS.

Based on CENS findings, this case presents analysis of best and worst-case scenarios, transitioning from scientific research to policy and data-driven decision-making, outlining important insights for science and policy for the best collaboration for soil health.

GT 17 - 763 - O

FROM EMPIRICAL TO REGRESSION-BASED PTF FOR THE CONVERSION OF 1:5 DILUTED ELECTRICAL CONDUCTIVITY TO SATURATED ECE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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The Soil electrical conductivity (EC) is a measure of the ability of soil to conduct electricity, and it can be used as a proxy for soil salinity. Soil salinity can pose a significant threat to crop growth, as high salt concentrations can alter soil structure by disrupting soil aggregates, leading to reduced aeration, and limiting root growth, also at earlier stages it can unbalance water uptake, interfere with nutrient assimilation. From the soil point of view, high EC can originate from genesis or secondary salinization in a given soil type and in various land uses.

The LUCAS soil module has until now analysed EC using the ISO standard ISO 11265:1994 - Soil quality — Determination of the specific EC, expected to be replaced by ISO/FDIS 11265 within the coming months. This standard measure the EC in soil water extract using a ratio 1:5.

As it was shown in several publications (e.g. Schillaci et al 2025) and references therein, the use of EC 1:5 is not reflecting the soil saturated EC therefore pedotransfer function (PTF) must be used to convert it, this can be used as indicator of soil salinity. This was the scope of our analysis which aims at generating a PTF based on a subset of soils to correctly interpret the 1:5 values in the context of the specific soil type, climate, and plant species.

This work is based on an assessment of soil EC using reduced amount of samples due to LUCAS soil archive limitation. To assess the agreement between the ECe calculated for 300 soil samples from 2018 LUCAS campaign analysed using a tailored methodology to reduce the soil sample quantity and previously used PTF.

The resuts of the lab analysis shows the following descriptives: resulted in ECe average 1.31 stdev 1.89, EC1:5 average 0,23 stdev 0.39.

LUCAS soil properties (EC 1:5, clay, SOC), measured in 18000 soil samples respectively, were used to build a general linear model, yielding an R2 of 0.87.

Preliminary results showed an underestimation of the previously used PTF in several soil types (e.g. Vertisols, Calcisol, Arenosols, and Andosol) compared to the new regression based approach (from 20 to 60%) Fig 1.. Maps with a 500m spatial resolution are made using Quantile regression forest in Schillaci et al (2025).

The analysis of LUCAS soil data across Europe by using using the procedure reveals a larger extent of ECe >4 ds/m across the most affected countries (Italy, Spain, and Cyprus), with some countries having higher Ece than before. New PTF is a valuable tool for monitoring soil with a reduced costs and the potential to browse from the legacy LUCAS soil datasets. This research will be instrumental for the future policy support of the Soil Monitoring Law.

ACKNOWLEDGEMENTS

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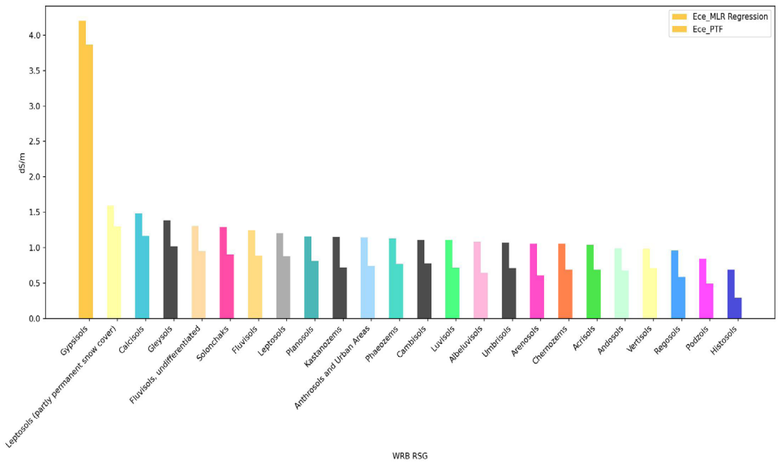


Fig. 1 left bars represent the average ECe value obtained by Multiple linear regression using the laboratory observation and EC 1:5, SOC and Clay as predictors, right bars the previously obtained ECe values obtained using literature coefficients (including SOC, Texture and coarse fraction) in the WRB RSG classes respectively

GT 17 - 771 - 0

EMPOWERING SOIL RESEARCH THROUGH VIRTUAL RESEARCH ENVIRONMENTS: LIFEWATCH ERIC SERVICES UNDER THE AGROSERV AND SUS-SOIL PROJECTS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Research Infrastructures, especially those recognized under the European Strategy Forum on Research Infrastructures (ESFRI), can contribute to advancing soil research by offering state-of-the-art scientific equipment and knowledge-based services and collaborative environments. LifeWatch ERIC, as the European Research Infrastructure Consortium for biodiversity and ecosystem research, supports this mission through a flexible digital architecture that enables access to distributed datasets, analytical tools and computing environments, fostering interdisciplinary collaboration and innovation across environmental and agroecological research.

Within the Horizon Europe-funded projects AgroServ and SUS-SOIL— the latter under the EU Mission Soil—LifeWatch ERIC develops and provides Virtual Research Environments (VREs) that empower researchers to integrate heterogeneous data, design workflows and collaborate across disciplines and regions. These digital platforms directly support agroecological transitions by enabling the modelling, monitoring and assessment of key soil functions.

A concrete application of this service is the VRE, created in collaboration with the University of Santiago de Compostela, to analyse soil and subsoil data with the goal of assessing how land use and management practices influence carbon dynamics—a vital element of climate change mitigation and soil health restoration.

The VRE integrates workflows that allow users to process, harmonise and visualise data for such analyses, with initial implementations based on the LUCAS datasets (Core and Topsoil modules), which offer a consistent, Europe-wide reference for soil data analysis. In collaboration with the University of Trás-os-Montes e Alto Douro, the platform is being further enhanced through stakeholder panel inputs resulting from the discussion and assessment of the VRE features and in order to align it with real-world needs, user experiences and diverse knowledge systems.

Co-designed and developed in collaboration with the research community, the VRE will represent a dedicated Soil Health module within LifeWatch ERIC's infrastructure. Designed to be flexible and responsive, it will continue to expand and evolve to the needs of the research community, enhancing the accessibility and usability of soil data, promoting standardisation across datasets and workflows, and accelerating the generation of actionable knowledge. Its user-driven and evolving design ensures scientific relevance, policy applicability, and long-term support for the emerging needs of researchers and decision-makers.

Ultimately, the VRE contributes to Europe's capacity to adopt sustainable land management practices and advance soil resilience in support of the EU Green Deal and its agroecological objectives, including those defined in the Farm to Fork Strategy, the Biodiversity Strategy and the EU Soil Mission.



GT 17 - 818 - O

ANALYSIS OF THE SUSTAINABILITY OF COFFEE PLANTATIONS IN THE MUNICIPALITY OF CUETZALAN DEL PROGRESO, PUEBLA, MEXICO.

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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In Mexico, the coffee activity is essential for some states of the country such as Cuetzalan, in which diverse productive systems have been established with different degrees of sustainability, the cooperatives that have been formed to produce coffee require research to indicate which system is the most sustainable under the social, environmental and economic conditions under which they cultivate. The general objective of this research was to analyze the sustainability of the different coffee growing systems in the Taposontok cooperative in the municipality of Cuetzalan del Progreso. Five methods of coffee cultivation were identified: monoculture under sun, commercial polyculture, traditional polyculture, monoculture under shade and rusticano. These have different types of shade and plant species, which can have different impacts on the environment and soil health, crop yield, economic benefits and the satisfaction of the basic needs of coffee growers. Soil and leaf samples were taken from 15 plots of the Taposontok cooperative (3 for each cultivation method). The physical, chemical and biological properties of the soil and nutrients in the coffee leaf were determined. An ANOVA test, Tukey and principal component analysis (PCA) were performed. Interviews were conducted to determine socioeconomic indicators and sustainability will be evaluated using the MESMIS evaluation framework. Principal component analysis was performed for the physical, chemical and biological elements of the soil and leaf elements. The greatest difference was found between Rusticano and the rest of the cultivation methods, since this system was related to the greatest number of variables of high contribution (>3.25%), within which, it presented the highest values of Fe (leaf), K (soil), actinomycetes, K (leaf), Na, P (leaf) and fungi. The conclusions show that the different coffee cultivation systems in the Taposontok cooperative that use the Rusticano method conserve soil health better than the rest of the systems, due to their relationship with different soil and leaf properties. The method tentatively presents the highest degree of sustainability, however, it is necessary to complement this with information from the surveys.

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GT 17 - 828 - O

A SPATIAL ANALYSIS OF HUMAN–SOIL INTERACTIONS USING REMOTE SENSING AND SOIL DATA: IMPACTS OF THE CONFLICT IN UKRAINE ON FOOD SECURITY

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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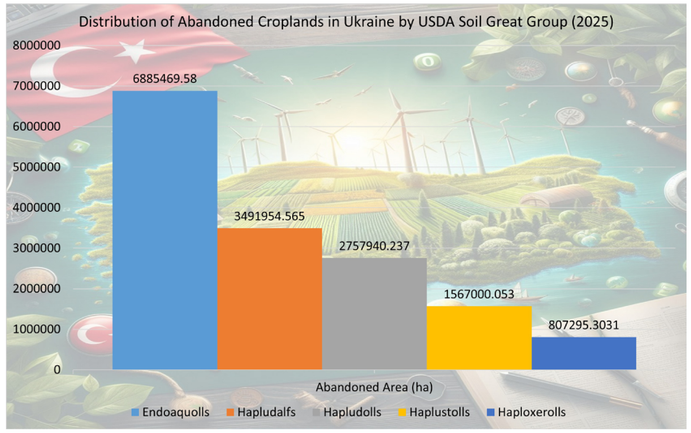
The ongoing conflict in Ukraine has led to severe disruptions in agricultural production, raising concerns about soil fertility, land-use changes, and global food security. This study aims to conduct a high-resolution and reproducible spatial analysis of how the conflict in Ukraine has affected human–soil interactions within agricultural areas. This study utilizes open-access data (Sentinel-2, ESA WorldCover, and OpenLandMap) on the Google Earth Engine (GEE) platform. Cropland areas were classified based on Normalized Difference Vegetation Index (NDVI) values for April 2021 and April 2025, separating between fallow and cultivated. A custom GEE code block was developed to analyze the spatial distribution of these areas according to the USDA Soil Taxonomy classification. The results show a significant decline in the average NDVI value from 0.358 (±0.191) in 2021 to 0.258 (±0.162) in 2025. The area of abandoned agricultural land increased from approximately 5.6 million hectares in 2021 to 17 million hectares in 2025, indicating a widespread cessation of farming activities in Ukraine. Soil group analysis revealed that this abandonment was concentrated in specific soil types. About 90% of the total abandoned land was found in just five soil groups: Endoaquolls (~6.89 million ha), Hapludalfs (~3.49 million ha), Hapludolls (~2.76 million ha), Haplustolls (~1.57 million ha), and Haploxerolls (~0.81 million ha). The decrease in NDVI variability indicates a spatial homogenization of croplands and a disruption of key ecosystem functions. The expansion of fallow croplands by 2025 indicates widespread abandonment of cultivation in Ukraine, with these lands concentrated primarily in Mollisol and Alfisol soil orders—groups known for their high fertility, organic-rich composition, and agricultural productivity potential. The abandonment of these fertile lands not only threatens local livelihoods but also poses significant risks to global food security. The results of this study show that conflict disrupts human-soil interactions, posing a substantial threat to global food security. As Ukraine's most productive Mollisols and Alfisols play a critical role in grain and oilseed production, their disuse directly impacts the stability of international agricultural commodity markets. The global consequences of such conflicts necessitate urgent international cooperation to safeguard food systems and avert food crises.

KEYWORDS

Ukrainian croplands, agricultural land abandonment, NDVI, USDA Soil Taxonomy, global food security, Google Earth Engine

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GT 17 - 856 - O

ROOTSS – INTRODUCING OPEN AND RESPONSIBLE RESEARCH AND INNOVATION (ORRI) IN SOIL SCIENCE: A HUNGARIAN CASE ALIGNED WITH THE EU SOIL MISSION

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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The ROOTSS (Responsible Open Soil Science) project is the first initiative in Hungary to apply the principles of Open and Responsible Research and Innovation (ORRI) to soil science, aligned with the objectives of the EU Soil Mission. The project responds to critical environmental and social needs in the village of Tiszaszentimre, where unsustainable farming practices dominate and awareness of soil health is low. According to Eurostat (2016), 95% of Hungarian agricultural land is conventionally tilled, contributing to widespread soil degradation and biodiversity loss.

ROOTSS addresses two main challenges: (1) the lack of soil literacy among farmers and (2) the low engagement of local communities in sustainable land use. Our approach is rooted in ORRI principles, emphasizing inclusivity, stakeholder co-creation, and the democratization of soil knowledge. By activating the Quadruple Helix model—involving academia, government, business, and civil society—ROOTSS fosters collaborative innovation through Living Labs, participatory mapping, field experiments, and dialogue workshops.

One of the key outcomes is the development of the ROOTSS Guide for Soil Health, a toolkit designed to help researchers, advisors, and community actors implement ORRI-based approaches in soil-related projects. The guide compiles best practices, methodological frameworks, and stakeholder engagement strategies that emerged during the project. It will serve as a replicable model for similar initiatives across Europe.

By embedding ORRI in soil science, ROOTSS contributes not only to healthier soils but also to more inclusive and socially responsive research processes. The project represents a scalable innovation for achieving the EU Soil Mission's target of restoring 75% of European soils by 2030.

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GT 17 - 863 - O

PEACE REGION LIVING LAB: A MULTI-STAKEHOLDERS INITIATIVE FOR AGRICULTURAL CLIMATE SOLUTIONS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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Producer participation in agricultural innovation is an important approach to sustainable agriculture in the context of global climate change, food security and consumer choices in domestic and international markets. Recognizing the strength of collaborative research, Agriculture and Agri-Food Canada (AAFC) has started the living laboratory Initiatives since April 2019. In 2021, AAFC renamed the program as Agricultural Climate Solutions (ACS). The priority of ACS program is to contribute to Canada's plan to reduce greenhouse gas (GHG) emissions by 30% below 2005 levels by 2030 and net-zero by 2050. Its objective is to find farm-level climate solutions that will contribute to reducing GHG emissions, mitigating effects of climate change, and supporting environmental benefits while increasing sectoral resilience. It has started Canada-wide Agroecosystem Living Lab (ALL) projects. The ALL is an integrative approach to agricultural innovation through collaboration with farmers, scientists, socio-economic experts and other partners to co-develop, test, and monitor new practices and technologies in a real-life context. It has envisioned that this approach will result in more rapid adoption of practical technologies, and sustainable farming practices by the Canadian farmers.

The Peace Region Living Lab (PRLL) is one of the cohort of ALL. The PRLL is a region-wide collaboration led by the Peace Region Forage Seed Association (PRFSA). Seven other producer groups have joined the PRSFA to bring together a project that will serve agricultural producers and land stewards of the region. The overarching goal of the project is to enhance agroecosystem services in the Peace River Region of Canada. The project focuses on four BMP categories including cover cropping, tillage management, nitrogen fertilizer management, and livestock integration in cropping systems. The PRLL is looking at agricultural operations as whole systems, considering land management, economic analysis and the social aspect of implementing innovative practices. Adoption of Beneficial Management Practices (BMPs) is expected to improve productivity, profitability and environmental resiliency.



GT 17 - 617 - F + P

HOW ARE PEOPLE IN EUROPE CONNECTED TO SOIL? OUTCOMES OF A SURVEY ACROSS EIGHT EUROPEAN COUNTRIES.

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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What are people's levels of knowledge, opinions and emotions about soil in Europe? What associations do individuals in different European countries have, when soil is addressed - be it in texts or images?

Answering these questions is part of the EU project SOILCAPE (2024-2028). Thus, a survey written in seven languages, including verbal and pictorial elements, was distributed in eight European countries in the networks of the project partners, including e.g., the German and French Soil Science Societies, and UNESCO. In addition, interviews were conducted with 24 people.

We found that images of landscape and nature symbolizing harmony of life and a life in relationship with nature have a strong positive emotional effect on many people. Images that represent people's physical contact with soil and nature also have a strong positive effect, independent of a cultural, everyday-life or educational context of that physical contact. Images of roots and soil biota can also have a positive effect. In general, strange but aesthetic images of nature usually stimulate strong curiosity. Also, a soil profile continues to arouse curiosity, especially among soil scientists. Regardless of the level of soil-related knowledge of a person, images of degrading and eroding soils are usually perceived negatively. Climate change, biodiversity loss, and the agricultural sector are regarded as major threats to healthy soils. Reduced tillage, agroecology, humus, unsealing, legal protection of soils, and social attention for soils are seen as positive. It became clear that own personal experience of nature strengthens the commitment to nature, that professional education shapes perception and that the recognition of good or critical soil conditions is partly intuitive and partly mediated by knowledge.

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GT 17 - 27 - P

ASSESSMENT OF PARTICULATE MATERIAL CONCENTRATION IN SMALL-SCALE MINING

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 03. SOIL BIOGEOCHEMISTRY & GLOBAL CHANGE

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Artisanal and Small-Scale Mining (ASM) are an important income source in many low- and middle-income countries, driving the economic sector of numerous municipalities in Brazil [1]. This extractive activity corresponds a large part of the Brazilian mineral sector, producing and benefiting resources such as clay, mineral aggregates, limestone, ornamental rocks, gems, and precious metals such as gold [2]. Mining activities, by altering the availability and speciation of metals in the surface, can affect local ecosystems and increase the exposure of workers and communities to potentially harmful elements (PHEs) and particulate material (PM), including minerals such as quartz – generally referred as silica - which is a rock-forming mineral and a gangue (waste) mineral in many of mined commodities [3,4]. The presence of silica is particularly concerning due to its capacity of causing silicosis and other respiratory diseases when inhaled over extended periods [5]. Objective: Characterize exposure risks, particularly to silica dust, in two distinct mine sites in Southern Brazil. Method: A collection system was positioned next to the conducting zone of the respiratory system of the volunteer workers for the research. Inhalable MP was obtained and accumulative changes of MP. The characterization of the particles was done through the use of a portable X-Ray Fluorescence equipment (EDXRF), Tracer III - SD model (Bruker, USA), equipped with a 4 W rhodium X-ray tube and a 10 mm2 X-Flash® detector, operating at a current of 30 μA and a voltage of 40 Kv, under vacuum [6]. Findings: The exposure limits, especially in the first assessment of mine 1, the three assessments of mine 2, and the assessment in the central region of the neighboring city, exceeded international (0.05 mg m^{-3}) [7] and national (0.1 mg m^{-3}) [8] silica standards for 8-hour workdays. In both mines the highest concentrations of MP containing silica occurred on Monday. This underscores the significance of appropriately depleting this material during the work shift, as the equipment is not operational at the end of the day and on weekends. Consequently, high levels of MP remain suspended in the air, posing potential risks when workers resume their activities on Monday.

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GT 17 - 55 - P

ADVANCING SOIL GOVERNANCE AND SUSTAINABLE LAND MANAGEMENT IN LEBANON: POLICY REFORMS FOR CLIMATE RESILIENCE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 06. SOIL PRODUCTIVE SECTORS: ECONOMY AND SUSTAINABILITY

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Soil health is fundamental to agricultural sustainability, climate adaptation, and ecosystem resilience, yet Lebanon faces critical challenges due to land degradation, institutional fragmentation, and policy inefficiencies. With escalating pressures from urban expansion, unsustainable agricultural practices, and climate change, soil governance remains fragmented across multiple agencies, leading to incoherent policies and ineffective conservation efforts. This study, conducted as part of the Soils4Med project, presents a comprehensive analysis of Lebanon's soil governance framework, evaluating its institutional weaknesses, legislative gaps, and governance inefficiencies. By integrating comparative global best practices, stakeholder insights, and policy assessments, a systemic approach to soil governance reform is proposed, emphasizing data-driven decision-making, cross-sectoral collaboration, and community-led conservation initiatives. The findings highlight the necessity for a unified national soil policy, digital soil monitoring systems, and climate-adaptive land management strategies. This research contributes to the Eurosoil 2025 agenda by offering actionable policy recommendations that promote long-term soil resilience, biodiversity conservation, and sustainable land use in Lebanon, bridging the gap between policy frameworks and on-ground implementation.

KEYWORDS

Soil governance, Lebanon, climate resilience, sustainable land management, policy reform, digital soil monitoring, land degradation, biodiversity conservation.

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GT 17 - 58 - P

PLANETARY HEALTH AND SOIL SCIENCE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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With 33% of global soils degrading moderately to severely, the relationship between soil health and planetary wellbeing has become critical as communities face dual challenges of food security and environmental sustainability. International frameworks emphasize reconciling agricultural productivity with ecological integrity. A systematic literature review was conducted using PubMed, Scopus, and Google Scholar, screening articles based on relevance, publication date, and quality. Key findings: (1) Yield-focused management diminishes soil's multiple ecosystem functions by 30-65%; (2) Integrated soil health techniques improve productivity, increase carbon content, and reduce erosion; (3) Region-specific regenerative approaches increase soil organic matter by 0.5-1.2% annually without yield penalties; (4) Each 1% increase in soil organic matter enhances water retention by 1.5-2.3%, improving climate resilience. Effective soil management must move from productivity-focused approaches to integrated frameworks recognizing multiple soil functions. Our proposed transdisciplinary framework emphasizes interconnections between soil systems, human wellbeing, and planetary boundaries, requiring integration across disciplines, policies, and stakeholder communities.

GT 17 - 121 - P

HU-SOILCARBONGRIDS: A NATIONAL INITIATIVE FOR PROVIDING COMPREHENSIVE SPATIAL AND TEMPORAL INFORMATION ON SOIL ORGANIC CARBON CHANGES IN HUNGARY

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 01. SOIL GENESIS, EVOLUTION AND CLASSIFICATION

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The ability of soil to store large amounts of organic carbon (SOC) is one of its most important properties, making it an active and indispensable participant in the global carbon cycle. SOC influences various soil-related functions, such as agricultural productivity, water retention and management and biodiversity maintenance, which are essential for providing nutritious food, clean drinking water and a healthy environment. Additionally, SOC plays a crucial role in mitigating and addressing various environmental challenges, including climate change, land degradation, declining biodiversity, and water and food security issues. Consequently, not only soil scientists but also researchers from other disciplines, practitioners, stakeholders, policymakers and even the broader society have shown growing interest in information on the spatial and temporal variability of SOC at various scales.

In the past few years, significant efforts have been made in Hungary to adapt, compare and implement advanced digital soil mapping techniques to predict the spatial, and more recently, the spatiotemporal variability of SOC. Recently, a space-time SOC model was developed using advanced machine learning and geostatistical techniques to annually predict SOC-content and -stock at a resolution of 100 meters across Hungary for the period 1992–2023. This research relies on soil observations from the Hungarian Soil Information and Monitoring System, which collects nationwide, geographically referenced biological and chemical data on the status and temporal change of Hungarian soils. Additionally, spatially and temporally exhaustive environmental covariates, serving as proxies for soil forming factors, were applied, with a distinction made between static and dynamic covariates over the study period. The performance of the developed space-time model was evaluated using cross-validation, yielding acceptable results. A series of SOC content and stock maps were compiled for 1992–2023, along with the quantified uncertainty, representing a significant advancement in Hungary. Moreover, the developed methodology overcomes limitations of recent space-time SOC modelling approaches, enabling the prediction of SOC and its change, with quantified uncertainty, for any year, time period and spatial scale. This capability addresses current and future demands for dynamic SOC information at national and international levels.

This presentation aims to outline the developed methodology, highlight some methodological challenges, present the resulting predictions and maps, and finally, but importantly, to discuss these findings in a broader context.

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GT 17 - 350 - P

THE FRENCH NETWORK FOR PARTICIPATORY SOIL SCIENCE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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Soils are essential to life on Earth, supporting among other services : food production, biodiversity, climate regulation, and public health. Today, they face increasing pressure from land use change, artificialization, and climate disruptions. Since about a decade a novel approach stands out to address these complex issues through an inclusive dialogue between scientists, educators, policymakers, technicians, and citizens.

In this context, participatory science—where non-academic actors contribute to knowledge creation—offers new ways to connect society with soil science. It enables scientists to access diverse, locally rooted data, while fostering citizen awareness and engagement. However, these approaches also raise specific challenges, especially around data quality, validation, and management. Designing shared protocols and tools is crucial to ensure both scientific rigor and accessibility.

To support and structure this growing dynamic, the French Soil Science Society (AFES)—a scholarly organization founded in 1934—was mandated by INRAE, OFB, and ADEME to coordinate the Participatory Soil Science Network (SRP Sols). Launched in 2021, this network aims at bringing together French-speaking project leaders, intermediaries, and mediators involved in participatory initiatives of soil research.

Nearly 40 participatory projects are already gathered across France, covering themes such as soil biodiversity, urban agriculture, mapping, and education. Notable examples include Clés de Sol: participatory soil mapping; JARDIBIODIV: soil biodiversity in urban gardens; IPAUP-93 : soil engineering in urban gardens, Rés'eau Sol: A field laboratory to adapt to climate change, OPVT: earthworm monitoring by citizen or QUBS: assessing urban soil biological quality.

The SRP Sols Network helps coordinate these efforts, facilitating the exchange of methods, tools, and experiences, while supporting the emergence of new co-designed projects. It promotes participatory soil science through newsletters, webinars, and events, and provides a space for mutual learning between scientists and citizens.

The network's mission, list of projects, and available resources can be explored on the AFES website: www.afes.fr/nos-missions/reconnaitre-et-federer/recherches-participatives.

By encouraging collaboration across disciplines and sectors, the SRP Sols Network strengthens the visibility, credibility, and impact of participatory approaches in soil science—supporting a more inclusive, responsible, and informed stewardship of soils.

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SRP SOLS Sciences et Recherches Participatives sur les Sols

GT 17 - 613 - P

HUMUS - HEALTHY MUNICIPAL SOILS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / · EU SOIL OBSERVATORY (EUSO) 5TH STAKEHOLDERS FORUM

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Global soil degradation reflects a lack of appreciation for the value of healthy soils for people and planet. Municipalities are at the forefront of local soil management, regulation, innovation, and community-building and are thus pivotal for promoting soil health.

HuMUS - Healthy Municipal Soils - is a 3-year project (2023-2025) funded under the European Union's Horizon Europe Research and Innovation programme and run by an international consortium of 18 partners.

The project engages and activates municipalities and regions to protect and restore soil health through the implementation of participatory processes at the local level, with the involvement of quadruple helix stakeholders.

RESULTS AND ACTIVITIES

- Resources on the HuMUS website on participatory governance, funding instruments, and funding opportunities for local soil health
- Regional soil health communities (RSHC) online
- Soil Stewards Training Programme
- 20 pilot projects selected and supported through an Open Call for proposals
- 14 territorial pilot cases of consortium partners
- 34 Territorial Management Agreements
- Catalogues of best practices and public policies to improve soil health
- A final conference in Brussels in September 2025

GOALS AND IMPACT

- Empower regional and local stakeholders to create contextual soil solutions
- Encourage social innovation
- Foster dialogue, capacity building, and exchange of best practices
- Analyse financial instruments available to improve soil health

PRINCIPLES

- Participation means that stakeholders and citizens take part in decision-making processes and their final products.
- In addition to raising awareness about soil health, the project empowers communities to create suitable local solutions for themselves and fosters stakeholder participation in decision-making.
- HuMUS focuses on all soil types and land use.

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https://www.humus-project.eu/

HuMUS poster 2024.pdf



GT 17 - 627 - P

SOIL CONSERVATION ROADMAP IN PALENCIA MODEL FOREST

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Raising public awareness is the first step in the conservation of any resource. In the case of soil, the importance that citizens attach to it is of vital importance because as it is underground, sometimes degradation is often not as visible as other problems. In in a participatory process with skateholders involved in Palencia Model Forest area, 8 forest resources were chosen in order to carry out management prescriptions in roadmap framework. One of them was soil conservation. For the elaboration of the roadmap, a bibliographic review of the main risks associated with the study area was carried out. Subsequently, a selection of management actions to eliminate or reduce the risks were evaluated. Finally, an interview was conducted with skateholders, culminating in the filming of an advertisement emphasizing the importance of soil in the ecosystem and advocating its conservation. These materials will be used for the realization of the roadmap for soil conservation.The involvement of society in these issues is of vital importance for all of us to move towards a more sustainable planet.

ACKNOWLEDGEMENTS

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GT 17 - 720 - P

POLICY INNOVATION FOR SOIL HEALTH: PATHWAYS TOWARD SUSTAINABLE LAND USE GOVERNANCE IN EUROPE

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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Soil degradation poses a critical threat to environmental sustainability and agricultural productivity across Europe (1). Soil health requires to address the issue of soil governance at more than farm level, to adequately tackle the challenge of providing multiple soil ecosystem services from agricultural land (2).

This paper explores the policy, legal, and institutional dimensions of soil health governance by synthesizing findings from the Policy Innovation Lab (3) organized within the NOVASOIL Horizon Europe project. We applied a mixed method approach by combining in depth-interviews and stakeholder workshops to a set of 13 case studies that were identified as sustainable business models for soil health across seven European countries.

We analyse the EU legal frameworks, policy coherence, and institutional environment by applying the OECD policy coherence framework (4) and by adapting an inter-institutional gaps analysis (5). Moreover, we synthetize findings over barriers, drivers and pathways towards sustainable business model implementation, individuated through a system innovation approach during the stakeholder workshop.

The study identifies significant challenges in coordination across policy sectors and various institutional gaps at national and regional scale. Moreover, limited soil advisory capacity and siloed incentive design does not help advancing soil heath at farm level. Yet our findings also highlight opportunities in promoting public-private partnerships, territorial governance models and emerging soil-specific outcomes for targeted incentive instruments, together with enhance monitoring systems through harmonized indicators and remote sensing.

We argue for the need of a holistic and harmonized soil governance framework to ensure sustainable land use and long-term soil health restoration.

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GT 17 - 796 - P

EMPOWERING COMMUNITIES TO COMBAT CLIMATE CHANGE: A CITIZEN SCIENCE APPROACH TO MONITORING AND MANAGING BARK BEETLE INFESTATIONS IN AUSTRIA'S FORESTS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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In academic and policy circles it is widely recognized that immediate adaptation to climate change is necessary in the forestry sector, but traditional wisdom and risk adverse attitudes may lead to catastrophic adaptation hysteresis. In Austria one of the biggest threats to both carbon stocks and forest health is bark beetle, which has boomed in recent years due to climate change and the fact that the beetle's host species Norway spruce (Picea abies) covers more than 50% of forested land.

It has been stressed that targeted systematic research that integrates and evaluates forest management strategies as well as promoting stakeholder and community engagement are important aspects of implementation of proactive land management for adaptation to future climate change. A citizen science approach can play a crucial role in addressing the challenges posed by climate change and bark beetle infestations in Austrian forests, as well as providing a platform for stakeholder integration and discussion. Through a series of soils education-based field days and stakeholder workshops with hands-on sampling; showcasing the latest scientific approaches, we aim to bring together a diverse range of actors in formal and informal settings to discuss and investigate the problems and solutions facing the sector. We want directly address these issues by building-up the multi-actor and stakeholder organizational capacity to deal with future climate change in the forestry sector and to strengthen the adaptation capacity in the system by providing evidence-based solution options and by building lasting coalitions and interconnecting the various players in the county of Lower Austria (NÖ). We want to inspire and galvanize both the general public and the small-scale foresters to adapt to climate change by highlighting their site-specific vulnerability and that climate change is happening by involving them in the collection and analysis of data and the development of appropriate adaptation pathways. To achieve this we are currently setting up a network of Forest Living Labs in NÖ to be researched over a number of years to feed sufficient quality data into the wider research knowledge base.

We will present the initial findings, as well as exploring and discussing the successes and challenges of creating such a proactive network.

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GT 17 - 845 - P

CONNECTING PEOPLE AND SOILS: A MISSION-ORIENTED ECOSYSTEM FOR SOIL HEALTH LIVING LABS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Healthy soils are the cornerstone of ecological resilience, sustainable agriculture, and rural vitality. Yet, despite their foundational role, soils remain undervalued in mainstream environmental strategies. The SOILL-Startup project addresses this gap by operationalizing the EU Soil Mission's ambition to establish 100 Soil Health Living Labs (SHLLs) across Europe. Anchored in a participatory, inclusive governance model, SOILL-Startup links diverse actors—including farmers, researchers, and local actors—through a harmonized support structure that facilitates collaboration, training, and community-driven innovation.

At its core, SOILL-Startup activates regional knowledge through Living Labs, while enabling cross-border knowledge exchange and community building. A digital Hub and collaborative platform connect stakeholders, promote mutual learning, and drive the uptake of nature-positive soil solutions. These digital tools, integrated with monitoring, matchmaking, and capacity-building systems, lay the foundation for a soil-centric innovation ecosystem.

Rather than viewing soil as a passive resource, SOILL-Startup recognizes soils as socio-ecological connectors—units where community action, scientific guidance, and regenerative practices converge. Through dedicated work on engagement, training, evaluation, and knowledge sharing, the project charts a replicable pathway toward regional soil health transitions, contributing directly to the Soil Mission's targets for 2030.

By connecting people and soils, SOILL-Startup supports a systemic transformation—where co-creation, equity, and landscape-level regeneration are not peripheral, but essential drivers of sustainable development.

KEYWORDS

Living Labs, Community Engagement, Agroecological Transition, Gender-inclusive innovation, Sustainable agriculture

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A Soil Deal for Europe



GT 17 - 866 - P

BARBANZA LIVING LAB: MULTIFUNCTIONAL MANAGEMENT AND COLLECTIVE CUSTODY OF THE TERRITORY IN GALICIA (NW SPAIN)

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 16. CONNECTING PEOPLE AND SOILS

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The forestry sector in Galicia (NW Spain) has a great importance, both in terms of the large area occupied by forests and their economic relevance. Lately, concerns regarding the forest environmental relevance are growing among forest owners and the society in general in this region. Private forest property represents here 80% of the forest area, but for the remaining 20% forests are communally owned, occupying around 650,000 ha which are managed mainly by forest owners' associations. This type of property allows the development of various community activities that can determine the collective use of the land and are of great educational interest. A living lab was established in the Barbanza area, mainly in Rianxo municipality (Galicia, NW Spain), within the framework of a Next Generation funded project. The seed of this living lab was the creation of the Platform for the Forest Protection, that gathers nine different forest owners' associations, which was born as a response for the shared concerns of the forest owners after the repeated wildfire events that desolate these forests every few years. One of the goals of the Platform for the Forest Protection was to transform their eucalyptus monoculture dominate forests by introducing diversified forest plantations and removing invasive species, mainly acacia, making their forests more resilient to wildfires. At the same time the forest owners' associations want to use the raw forest materials and transform it in products with an added value such as using them as amendments to improve the fertility of these acidic, nutrient-poor soils and increase C sequestration.

The project embedded in this living lab includes the mentioned Platform, three research groups from two different universities (Santiago de Compostela y Pablo Olavide de Sevilla), and two non-profit foundations (RIA y Montescola). To achieve the Platform goals, within the scope of this project, on one hand researchers performed different analysis to select the most appropriate management models, on the other hand, the foundations have a key role integrating the project within the social dynamics, specifically, through formation activities, community foresight, volunteering and environmental education. Our task in this project is related to the transfer to communities' knowledge about strategies to improve of soil fertility, in this case specifically through the use of local by-products and about the forest potential C sequestration and improved forest management to increase it. We have performed different activities in collaboration with the Platform for the Forest Protection which included the establishment of an experimental plantations were different strategies to improve soil fertility were tested, or the educational talks performed at schools and high schools.

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GT 17 - 878 - P

THE USE OF CROWD-MAPPING TOOL TO EDUCATE THE COMMUNITY AND IDENTIFY SOIL DEGRADATION PROBLEMS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 09. SOIL HEALTH

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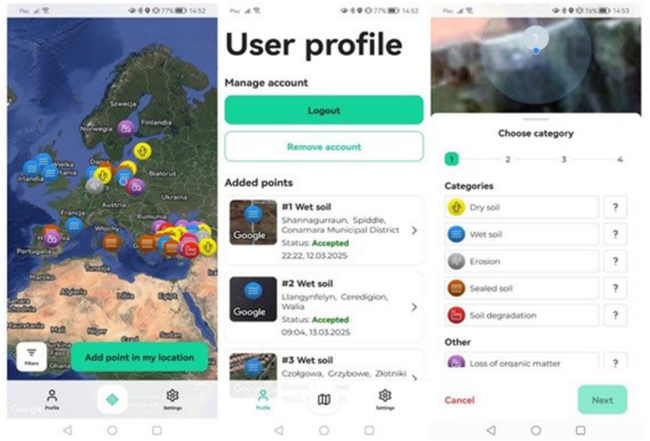
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The LOESS project "Literacy boost through an Operational Educational Ecosystem of Societal actors on Soil health, funded by the European Union (project no 101112707 — LOESS — HORIZON-MISS-2022-SOIL-01)" focuses on increasing soil literacy, via developing educational offers and continuous training programs as well as skills development activities addressing multiple actors, stakeholders and target groups connected to soil education. The crowd-mapping tool is a participatory method to gather insights into perceptions of soil related problems by leveraging interactive maps and geolocation tools. It can collaboratively build a database by adding information about soil conditions in their local areas. This tool help us to indicates areas with problems related to drought, excessive moisture, erosion, soil sealing, loss of organic matter, pollution, pH problems, or loss of biodiversity occurring locally. Crowd-mapping focuses on topics that require the know-how of local people to give scientific insights a face. The LOESS tool is available on: https://loess-project.eu/crowdmapping-tool/ or in iOS store (LOESS Soil Map). For the first time, the user registers using only their email address. Each time they access their profile, a unique access code is sent to their email, valid for 2 hours. No password or personal information is needed. User has to register using only e-mail address. The user, indicating the location of the problem, can describe the problem, give the probable cause of the issue (from the selection menu), add a photo and mark the affected area by the described problem. This tool is available in 14 languages: English, Catalan, Dutch, Greek, German, Hungarian, Italian, Lithuanian, Polish, Serbian, Slovak, Spanish, Swedish, Turkish. We encourage you to test and promote in various communities.

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GT 17 - 930 - P

CHANGES IN THE PERCEPTIONS AND PRACTICES OF OLIVE OIL AND WINE PRODUCERS THROUGH PARTICIPATION IN MULTI-ACTOR PROJECTS ON SUSTAINABLE SOIL MANAGEMENT

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 17. EUROPE: RESEARCH, EDUCATION, COMMUNICATION & POLICY

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Millions of people worldwide live in situations of food vulnerability, which are expected to worsen in the future due to population growth and increased soil degradation. It is urgent to implement sustainable soil management (SSM) practices. However, the adoption of SSM by farmers remains a challenge due to multiple factors: values, traditions, ambitions, as well as agronomic, financial, and policy-related barriers. Social learning has emerged as a crucial enabler, valuing farmers' perceptions of their agricultural practices. Multi-actor approaches—through collaborative and transdisciplinary projects—represent an opportunity for knowledge exchange, innovation, and practice sharing, thereby promoting the transition toward sustainable practices.

This study aims to measure changes in perceptions among wine and olive oil producers in Portugal who are involved in two scientific projects promoting sustainable agricultural practices, with a focus on soil erosion protection. Specifically, the SOLVO and SOLVIT projects promote the introduction of sustainable farming techniques such as organic mulching, biochar application, and composting, with the aim of improving soil health and mitigating erosion.

Methodologically, the study employs semi-qualitative scientific research techniques, including individual interviews and the analysis of Fuzzy Cognitive Maps (FCM). The goal is to identify the factors influencing land degradation, agricultural production, and the perceived impacts of soil restoration practices from the farmers' perspective. The use of FCM allows for measuring, evaluating, and understanding changes in perceptions regarding soil degradation and restoration practices, before and after active involvement in the projects.

By shedding light on changes in perception, this study contributes to advancing the understanding and effective implementation of SSM initiatives. Preliminary results show that, in the Portuguese context, producers are familiar with best SSM techniques. However, their implementation requires tangible examples that can serve as demonstrations for stakeholders.

KEYWORDS

Desertification, soil restoration practices, ecosystem services, co-construction of knowledge, multi-actor platform, transdisciplinarity

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GT 17 - 1066 - P

CONCEPTUAL AND METHODOLOGICAL FRAMEWORK FOR THE STUDY OF PSYCHOSOCIAL FACTORS SHAPING RAINFED AGRICULTURAL SOILS

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 15. CROSS CUTTING, EMERGING & TRANSDISCIPLINARY TOPICS IN THE SOIL

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Changes in soil properties resulting from agricultural practices have been extensively studied. Nevertheless, despite the available factual and empirical evidence, many techniques that yield detrimental impacts on farms' performance and the environment persist as entrenched habits and traditions in contemporary agriculture. The question that arises from these observations is obvious: 'If we "know how to fix the problem," why don't farmers just do it?' (Baveye 2022, p 4).

A possible answer is that conclusive explanations for why and how farms' soils condition depend on human activity are still lacking. This research aims at addressing precisely this knowledge gap. The corresponding objetive defined in the research project is to institutionalize the human factor within the clorpt model of (Jenny 2011) state factor theory, as outlined by (Amundson & Jenny 1991). This requires expanding the search for mechanisms that determine the configuration of agricultural soils beyond the natural processes triggered by agricultural practices (human behavior). Specifically, social and psychological factors mediating and moderating farmers behavior must be integrated into the causal chain.

A comprehensive conceptual and methodological framework for this interdisciplinary research is provided. In this regard, given that the research object includes psychological and social facts (people interacting with their environments), social psychology and environmental psychology become relevant for this study. Thus, social psychology theories such as Moscovici's social representations enable the study of common-sense knowledge construction in farmers' communities of practice. In the same sense, environmental psychology theories like (Kaplan 1983) psycho-environmental model of person-environment compatibility and (Corraliza y Berenguer 2000) situational approach facilitate the study and understanding of human behavior, by analyzing the interactions between personal and situational variables. In addition, Mario Bunge's philosophical system provides tools for systems modeling and concepts definition, while branches of linguistics, such as pragmatics and computational linguistics, and different UML diagrams do the same to carry out qualitative and quantitative analysis of transcriptions corpora, to delimit the actors' personal and situational variables and to model the depicted systems.

Finally, illustrative examples of the application of this conceptual and methodological framework to the case study of rainfed cereal agriculture in Spain are presented.

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GT 17 - 1098 - P

DEVELOPMENT OF A DECISION-SUPPORT TOOL FOR FOREST SPECIES SELECTION: AGGREGATING SOIL MOISTURE AND NUTRIENT REGIME DATA FOR THE CREATION OF A PORTUGUESE ECOLOGICAL SITE CLASSIFICATION (ESC)

GT 17. SOILS AT THE CROSSROADS: SOCIETY, POLICIES, AND PARTICIPATORY SCIENCE / GT 14. SOIL DATA ACQUISITION, CURATION, SHARING & MODELLING

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This work presents the development of an online decision-support tool for forest species selection, grounded in the Ecological Site Classification (ESC) methodology. The tool aims to support adaptive forest management by matching species to site conditions based on a combination of climatic, edaphic, and ecological variables.

The platform integrates species performance data from the REINFFORCE project, which established a pan-European arboreta network to assess the resilience of forest species under climate change. It also incorporates bibliographic species profiles and species distribution data from the EPIC project (Instituto Superior de Agronomia, University of Lisbon), which maps the ecological suitability of forest species across Portugal.

A key component of this work is the creation of a national database of soil moisture and nutrient regimes for continental Portugal. This was achieved by combining the National Forest Inventory (NFI) photopoint grid with soil cartographic data from SNISolo and EPIC Web-GIS Portugal using a Geographic Information System (GIS). Each NFI photopoint was associated with a pedological unit, and soil water availability and nutrient status were estimated using descriptive memos and analytical data from soil profiles, when available. By integrating this information with topographic and orientation data, the tool defines the soil moisture and nutritional regimes at each location.

This soil-based classification enables the tool to recommend forest species that are ecologically suited to the specific pedological context. The resulting information will be made publicly available through a digital platform. Additionally, users will have the option to input their own soil data to receive tailored species recommendations for afforestation or reforestation planning.

By combining empirical field data, literature-based species traits, and spatial distribution models, the tool provides a robust framework for selecting climate-resilient and site-appropriate species, supporting sustainable forest management across Portugal.

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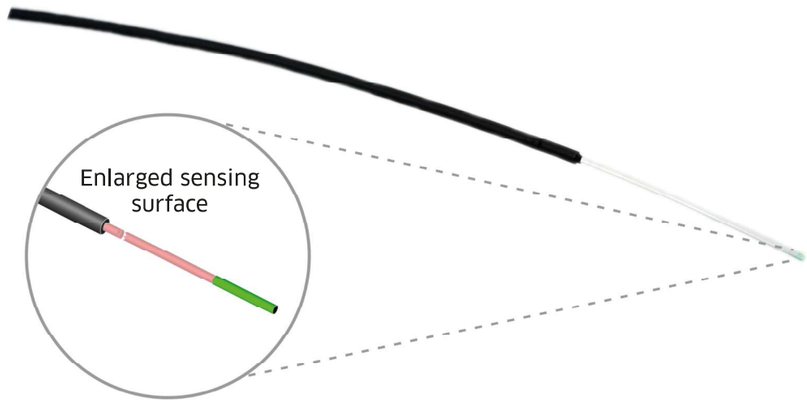
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