EUROPEAN HEALTHY SOILS

Sept. 13–15, 2023
Muttenz, Switzerland

1st Edition: Soil Fertility

Conference Booklet 2023

ORGANIZED BY:

n|w University of Applied Sciences and Arts Northwestern Switzerland

Agroscope

efb | european federation of biotechnology

European Healthy Soils Conference 2023 - First Edition

WILLKOMMEN IN MUTTENZ!



Dear Participants,

We are excited to welcome you to the European Healthy Soils Conference Series First Edition with a focus on Soil Fertility.

It is a pleasure to host this event in Muttenz at the FHNW, School of Life Sciences, in a region in the center of Europe with a strong economic, cultural, and scientific heritage.

Healthy soils are in many ways the foundation of our economy, and our culture. They are not only a basis of our food production but also fulfill numerous other functions as they enable microbial, animal and plant biodiversity; purify and store water; and modulate increasingly alarming greenhouse gas emissions. Despite these well-known benefits, healthy soils are under pressure from intensive agriculture, sealing and pollution; from extreme environmental events; and from carbon loss. We therefore must develop means to sustain healthy soils, not only in Europe but across the world.

What determines a healthy soil? How can we understand, monitor and maintain soil diversity? What is the underlying chemistry, biology and soil physical structure required to maintain sustainable crop cultivation and management? What are the main challenges to healthy soils? How is climate change challenging soil health, and how can healthy soils help mitigate climate change?

To raise and discuss these and other questions, this conference brings together soil scientists, along with stakeholders from industry, agriculture, and the public sector to identify and propose opportunities for healthy soils now and in the future.

Over 30 international speakers will address a broad spectrum of aspects of soil health, ranging from challenges, to monitoring to technical solutions for maintaining soil health. Participants will dicusss indicators of healthy soils during one workshop, aiming to contribute to the discourse through multi-stakeholder engagement. In the pre-conference workshop, regenerative agriculture will be discussed as one way of maintaining healthy soils in agriculture. We will hear national, European, and international perspectives about the integration of programs promoting soil health.

We are proud that you are joining this conference to share your perspective, be it as an experienced scientist, an enthusiastic student, or an industrial, policy or legislative professional. We wish you an excellent event!

Sincerely yours,

Organizing Committee 2023

Sebastian Wendeborn, Head, Institute for Chemistry and Bioanalytics, FHNW School of Life Sciences
Reto Meuli, Former Head of National Soil Monitoring NABO Research Group, Agroscope
Thomas Gross, Agroecology and Environment Research Group, Agroscope and Institute for Ecopreneurship, FHNW School of Life Sciences
Alexander Wissemeier, Assistant Professor, Leibniz Universität Hannover

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University of Applied Sciences and Arts Northwestern Switzerland
School of Life Sciences

Institute for Chemistry and Bioanalytics

FHNW School of Life Sciences

Research at the interface between nature, technology, medicine and the environment

Producing and characterising new substances – developing and applying new test systems.

Applied analytics, molecular bioanalytics, and cell biology

- Microbiology and microbiome interactions
- Test systems based on molecular interactions
- Metabolomics
- Analysis of small molecules and particles

Chemistry and biotechnology

- Proteins, peptides, and bioconjugates
- Plant chemistry and biochemistry for crop enhancement
- Nitrogen-use efficiency for zero emissions
- Membrane technology
- Fungal, bacterial and algae fermentation and downstream processing
- Natural product extraction

Please visit our website to learn more about our fields of research.

University of Applied Sciences and Arts Northwestern Switzerland
School of Life Sciences

Institute for Ecopreneurship

FHNW School of Life Sciences

Research at the interface between nature, technology, medicine and the environment

Developing environmentally friendly production processes and methods for cleaning, treating and recycling waste and wastewater.

Environmental and water technologies

- Resource recovery and recycling
- Adapted and near-natural treatment concepts

Environmental biotechnology

- Bioremediation
- Fate of pollutants

Ecotoxicology and biotechnology

- Effects of single and multiple substances on organisms
- Bioassays in wastewater management

Applied circular economy

- Biohydrometallurgy
- Hydrometallurgy

Sustainable resources management

- Resource recovery from biowaste
- Sustainability assessment

SCIENTIFIC PROGRAM

Wednesday September 13, 2023 AM

8.00	Exhibitor set-up
8.30	Registration

	Pre-conference Workshop: Upscaling Regenerative Agriculture Chaired by Pascal Boivin, HEPIA
9.00	Welcome Pascal Boivin, HEPIA
	Stances on regenerative agriculture – Input talks
9.10	The Soil health Framework (SHF) developed for Nestle Pascal Boivin, HEPIA
9.25	Earthworm's Living Soils program Bastien Sachet, Earthworm
9.40	Regenerative agriculture as part of climate roadmap Thomas Peyrachon, Nestle
9.55	Regenerative agriculture from the farmers outlook: a welcome discussion that requires buy-in Niall Curley, COPA Cogeca
10.10	Regenerative agriculture as part of the EU Mission A Soil Deal for Europe Luis Sanchez Alvarez, Directorate-General for Agriculture and Rural Development, EU Commission
10.30	Coffee break
	Round table discussion
11.00	• What are the major limitations in upscaling regenerative agriculture? • What are the goals and expected achievements? • What is the relative importance of new technologies, systemic research, and management schemes? • What pain points and limitations are we facing? • What are the major expectations from research, what is the role of living labs? • What are the available frameworks, standards and labels, to what extent are they compatible? • What is the role of the value chains, and how can they collaborate?
12.00	Lunch, networking, posters, exhibition

SCIENTIFIC PROGRAM

Wednesday September 13, 2023 PM

	Main Conference – Opening Session
13.00	Welcome to the FHNW: Sebastian Wendeborn
13.05	Swiss perspective: Eva Reinhard, Head, Agroscope
13.15	Swiss perspective: Kathrin Schweizer, Councilor and Head of the Basel-Landschaft Security Department
13.25	European perspective: The EU mission - A Soil Deal for Europe Peter Wehrheim, Directorate-General for Research and Innovation, EU Commission
13.45	International perspective: Food and Agriculture Organization of the United Nations (video)
	Soil Diversity Chaired by Reto Meuli, Agroscope
13.50	Opening keynote: The soils of our planet – a fascinating resource Peter Schad, TU München
14.35	Keynote: Accelerated soil development – a key process to understand future biogeochemical cycles in arctic and alpine environments Sebastian Dötterl, ETHZ
15.20	2930: Cropping practices and soil quality as drivers of soil microbial communities Alyssa Deluz, HEPIA
15.40	Coffee break
	Chemistry and Microbiology in Agronomical Soils for Sustainable Crop Cultivation Chaired by Sebastian Wendeborn, FHNW
16.00	Current priorities and perspectives for soil health in the UK Rich Stone, Department for Environment, Food & Rural Affairs, UK
16.10	Plenary: Climate and management impacts on mycorrhizal function in crops Katie Field, University of Sheffield
16.40	2998: Buried underpants as soil health indicator and awareness-raising tool using citizen science and ways to harness soil biological functions for agriculture Franz Bender, Agroscope
17.00	2929: Compost-based soil amendments for a sustainable agriculture: linking soil biochemistry and microbiome responses Elena Biagi, University of Bologna

SCIENTIFIC PROGRAM

Wednesday September 13, 2023 PM

	Flash Poster Presentations - Moderated by Thomas Gross and Reto Meuli
17.20	Sponsor introduction: Syngenta
17.30	2951: Profiling the impact of crop protection products on mycorrhizae Ben Oyserman, Syngenta
17.35	2939: To inoculate or not to inoculate: predicting the effect of field inoculations with arbuscular mycorrhizal fungi on maize yield Stephanie Lutz, Agroscope
17.40	2952: Impacts of veterinary pharmaceuticals on plant-mycorrhizal symbioses in the environment Emily Durant, University of Sheffield
17.45	2962: Root traits explain multitrophic interactions of belowground microfauna on soil nitrogen mineralization and plant productivity Junwei Hu, University of Gent
17.50	2942: Siderophores-based biofertilizers as a valuable complement/alternative to chemical fertilizers, soil regenerators and plants' biostimulants Klaudia Debiec-Andrzejewska, University of Warsaw
17.55	2947: Further Testing of the Fungicide Fluazinam – Effects on Three Non-Target Species Micha Wehrli, University of Gothenburg
18.00	2932: Restoring soil health through irrigation technology Javier Meyer, Aqua4D
18.05	3032: Autoencoder Neural Network to monitor soil status and analyze the change in soil water dynamics Nedal A. T. Aqel, ETH Zürich
18.10	2941: Soil and climate change: the role of soil organic amendments in carbon sequestration Melania Fiore, Politecnico di Torino
18.15	3037: Voluntary Carbon Standard program and methodology for soil carbon quantification Carolina Cardoso Lisboa, Verra
18.20	3055: Evaluation of new anion exchange and synthetic carbon sorbents for the determination of PFAS in solid samples following EPA method 1633 Sarah Hohlmann, Agilent
18.25	2945: Soil quality as driven by cropping practices under intensified agriculture in the north of France – large scale on-farm study Pascal Boivin, HEPIA
18.30	Welcome Apéro – 12th floor

SCIENTIFIC PROGRAM

Thursday September 14, 2023 AM

8.00	Registration
8.30	Welcome Day 2
	Chemistry and Microbiology in Agronomical Soils for Sustainable Crop Cultivation Chaired by Sebastian Wendeborn, FHNW
8.45	Plenary: Effects of multiple threats on soil processes and biodiversity Matthias Rillig, Institute für Biologie, Freie Universität Berlin
9.20	2937: The ConSoil project - developing a biomonitoring approach to evaluate the risk of Plant Protection Product residues to soil fertility in agricultural soils Mathieu Renaud, EcoTox Center, EPFL
9.40	2961: Remote sensing of cover crop legacies on soil health and main crop N-uptake dynamics Nikolaos Christos Vavlas, Wageningen University
10.00	Coffee break
	Today's Challenges to Soil Health Chaired by Fabio Fava, FHNW
10.30	Plenary: Soil regeneration and circular bioeconomy Catia Bastioli, Novamont
11.00	Plenary: Living labs and soil needs assessments in support of EU Mission: A soil deal for Europe Niels Halberg, Danish Centre for Food and Agriculture
11.30	2959: Microplastic pollution in agricultural soil: application of hyperspectral imaging and artificial neural networks Misato Toda, FHNW
11.50	2964: The climate challenge of managing organic soils Jens Leifeld, Agroscope
12.10	Lunch

SCIENTIFIC PROGRAM

Thursday September 14, 2023 PM

13.15	Plenary: Global fertilizer crisis: challenges and opportunities for boosting soil health Natalia Rodriguez Eugenio, Food and Agriculture Organization of the United Nations (FAO)
	Workshop: Soil Health - From Practical Issues to Indicators
	Part A: Definition and Threats, moderated by Natalia Rodriguez Eugenio and Bettina Hitzfeld
13.45	Workshop question 1: What are the biggest threats to soil health? Mentimeter Ranking Exercise – 10 Global Soil Threats • Soil erosion • Soil organic carbon loss • Soil nutrient imbalance • Soil salinization • Soil contamination • Soil acidification • Loss of soil biodiversity • Soil sealing • Soil compaction • Waterlogging
13.50	Workshop question 2: What is healthy soil for you? Your definition of a healthy soil?
	Part B: Input Talks – Threats, moderated by Alexander Wissemeier and Natalia Rodriguez Eugenio
13.55	2935: NETmicroplastic in agricultural soil and its impact on soil properties Claudia Preininger, Austrian Institute of Technology
14.00	2954: Greenhouse cultivation practises affect soil health indicators Beatrice Kulli, ZHAW
14.05	2956: Monitoring carbon stocks in arable land: sources of errors, improvement of the one-layer equivalent soil mass method and minimum detectable change Pascal Boivin, HEPIA
14.10	Discussion: Threats
14.30	Coffee break – Vote on definitions

SCIENTIFIC PROGRAM

Thursday September 14, 2023 PM

	Part C: Minimum indicators and metrics, moderated by Alexander Wissemeier and Bettina Hitzfeld
15.00	Workshop question 3: What is the set of minimum indicators and metrics?
15.05	2926: From science to applications: Global demonstration of microbiome properties as a bioindicator linked to differential management practices Sam Röttjers, Biome Makers
15.10	2933: Predicting soil fungal communities from chemical and physical properties Natacha Bodenhausen, FiBL
15.15	2938: Automatic soil biology analysis by computer vision Tobias Heinrich, OTH Regensburg
15.20	2940: Measuring soil quality indicators by means of visible and near-infrared spectroscopy Konrad Metzger, Agroscope
15.25	2944: Characteristic times of soil water partitioning as soil health indicators Peter Lehman, ETH Zürich
15.30	Discussion: Minimum indicators and metrics
	Part D: Thresholds for chemical, physical, and biological parameters, moderated by Natalia Rodriguez Eugenio and Alexander Wissemeier
15.50	3054: Determination of per- and polyfluoroalkyl substances in soils using Agilent carbon S SPE by LC/MS/MS Holger Stalz, Agilent
15.55	3044: Soil quality and management evaluation of Swiss agricultural soils – the Bodencockpit project Franziska Häfner, Agroscope
16.00	2948: BENCHMARKS - Building a European network for the characterisation and harmonisation of monitoring approaches for research and knowledge on soils Fabio Volkman, Climate Farmers and Wageningen University
16.05	2960: Setting targets and thresholds for soil health indicators Amanda Matson, Wageningen University
16.10	Discussion: Thresholds and parameters
16.30	Workshop Wrap-Up Discussion – All Participants
	• How do we define healthy soils? Vote on definitions. • What methods, tools, and indicators need to be developed? • How do we put indicators into practice? • What can we do after this workshop to keep our momentum going? • Each person submits quote for white paper

	Poster display and beer
17.30	Sponsor introduction: Anglo American

SCIENTIFIC PROGRAM

Friday September 15, 2023 AM

8.30	Registration
9.00	Welcome Day 3
	Soil and Climate Change: Interaction of Soil with Water and Atmosphere Chaired by Thomas Gross, Agroscope
9.10	Keynote: Soil organic carbon management in agriculture - potentials and limitations Axel Don, Thünen Institut
9.50	2931: Modified soil erodibility global map using saturated hydraulic conductivity Surya Gupta, University of Basel
10.10	Coffee break
10.40	2936: 3D+T mapping in the Netherlands reveals soil organic matter changes between 1953 and 2022 at 25m resolution Anatol Helfenstein, Wageningen University
11.00	2958: Deep-rooting cover crop mixtures: Highways to subsoil water and nutrient resources Sandra Spielvogel, Christian-Albrechts-Universität zu Kiel
	Conclusion
11.20	Closing plenary: How the EU Soil Observatory is providing solid science for healthy soils Alessandra Zampieri, Directorate for Sustainable Resources of the European Commission’s Joint Research Centre (JRC)
12.00	Poster award and announcement of next conference
12.30	End of the event

PRE-CONFERENCE WORKSHOP: UPSCALING REGENERATIVE AGRICULTURE

Organized by:

PASCAL BOIVIN

Group Leader, Soils and Substrates
Institut Terre-Nature-Environnement
HEPIA, HES-SO Genève

WORKSHOP DESCRIPTION

The theme of regenerative agriculture has been steadily gaining steam and the aim of this workshop is to bring stakeholders together to make joint advances in this area.

The workshop will feature input talks from academia, farmers, the food industry, NGOs, and policy makers to set the table.

This will be followed by an interactive discussion where participants can share challenges, insights and opportunities.

The workshop will address questions such as:

- What are the major limitations in upscaling regenerative agriculture?
- What are the goals and expected achievements?
- What is the relative importance of new technologies, systemic research, and management schemes?
- What pain points and limitations are we facing?
- What are the major expectations from research, what is the role of living labs?
- What are the available frameworks, standards and labels, to what extent are they compatible?
- What is the role of the value chains, and how can they collaborate?

REGENERATIVE AGRICULTURE: INPUT TALKS

PASCAL BOIVIN

Group Leader, Soils and Substrates
Institut Terre-Nature-Environnement
HEPIA, HES-SO Genève

The Soil Health Framework (SHF)

ABSTRACT

The Soil Health Framework (SHF) has been designed to enable Nestlé to implement regenerative agriculture on a global scale. It is designed to allow for a rapid upscaling of soil regeneration in Nestlé's supply chain. Among the specifications, it must be applicable by non-specialists, flexible to adapt to all climate, soil, and cropping system conditions, requiring few facilities if any, and be compatible with result-based management of the cropping system and its ecosystem services. In addition, links with other existing frameworks should be easy to establish.

The SHF indicators were selected accordingly, using three levels of growing expertise, from minimum through nice-to-have to advanced. The SHF uses modern indicators such as the organic matter to clay ratio. The desirable values of these indicators are determined by local top quality reference soil properties, or standard values when a local reference was not available. The gap between reference soil health and observed cropped soil health is linked to simple indicators of the cropping systems, which allows to support the decision making in favor of more regenerative cropping systems. The cropped soil health is monitored with these indicators and the reference properties are updated whenever a higher soil health is found or achieved. The SHF has been successfully tested on 5 pilot sites in Pakistan (dairy), Chile (cereals), Vietnam and Côte d'Ivoire (coffee) and Switzerland (mixed farming), integrating different soil types, climates, and cropping systems. We believe that the SHF makes it possible to launch soil regeneration on a large scale and opens the door to increased local expertise. It also highlights the various areas of technical support needed to help farmers make this transition, from reliable and inexpensive soil analyses to adapted machinery and cover crop seeds, for example.

BIOGRAPHY

Pascal Boivin is professor of Soil Science, president of the European Confederation of Soil Science Societies. He is leading research in soil physics, on soil quality indicators, soil quality management, and regenerative agriculture. With his group, he is focusing on the impact of soil organic carbon and soil organic carbon forms on soil physical and biological quality, and on how farming practices influence soil quality and soil organic carbon content.

REGENERATIVE AGRICULTURE: INPUT TALKS

BASTIEN SACHET

Chief Executive Officer
Earthworm

Earthworm's Living Soils Program

ABSTRACT

Earthworm - a Swiss foundation that operates worldwide - has developed a program called Living Soils, initially in France and now spreading internationally to the UK, Spain, USA and India. Living Soils aims at fostering soil health and accelerating the adoption of regenerative agricultural practices. It brings together businesses that sources various raw materials around the crop rotation of the farmer to work collectively on this common goal. By working collectives, a systemic approach to the agro-ecological transition can be adopted and it becomes possible to talk about a regenerative farm rather than sustainable wheat....

Living Soils is built around three key pillars: 1. Measure 2. Technical support to farmers and 3. Economic incentives. The measurement indicators for soil health, carbon, biodiversity have been developed with the support of a scientific committee and in a co-design with farmers. Today the program involves 500 farmers and various companies such as Nestlé, McDonalds, LIDL, Mc Cain and is in a phase of scale up. It aims to impact 10'000 farmers by the end of 2025.

BIOGRAPHY

Bastien became CEO in January 2016, which marked his tenth year at Earthworm Foundation. He began working at Earthworm Foundation as a member manager before becoming a director in 2011. His background and experience in business and agriculture are well linked to Earthworm Foundation's work between two worlds of business and nature. He has helped to coordinate Earthworm Foundation's palm oil strategy, heading up teams in France, Switzerland and Africa, and launching the Rurality programme, which works to empower smallholder farmers. In 2018 he launched the Living Soils initiative, dedicated to accelerating regenerative agriculture and soil health. Prior to joining Earthworm Foundation in 2006, Bastien worked for several years in Brazil, Australia, England and Argentina, where he led product and sales teams in logistics and agro-business for Hamburg-Sud and the Roullier Group respectively. In 2000, Bastien graduated in agricultural engineering from the Institut National Agronomique Paris-Grignon (Agro Paris Tech). He then completed his postgraduate degree in marketing and strategy at the University of Paris IX Dauphine.

THOMAS PEYRACHON

Regenerative Agriculture Manager
Nestle

Regenerative agriculture as part of climate roadmap

ABSTRACT

As part of its journey towards net zero, Nestlé set itself an ambition to source 50% of its key ingredients from regenerative agriculture by 2030. This represents a significant effort to engage farmers and suppliers and then scale-up regenerative agriculture practices across many different countries, crops, and farming systems. To enable this, it is therefore critical that we deploy innovative tools and processes that are scientifically robust, yet that also remains practical enough to be implementable at local level in various context across large and small-holder farms. The focus on soil health is fundamental to the success of the regenerative agriculture journey and it requires continuous improvements. That is why we wanted to equip our agronomists, partners and farmers around the world with a simple step-by-step guide such as the soil health framework. It helps local teams to start assessing soil health and identify opportunities of improvement with a minimum set of indicators, while also providing guidance on more advanced approaches for continuous progresses. The framework will be implemented globally, in temperate and tropical climate zones, with the aim to improve soil quality for agricultural production over time.

BIOGRAPHY

Thomas Peyrachon is Regenerative Agriculture Manager at Nestlé. He possesses over 20 years of international experience in agricultural development an agri-business roles. His experience spans national, regional, and global projects in Europe, Latin America and Asia Pacific regions, with positions in established businesses and new start-up ventures, ranging from seeds (Limagrain), crop protection (Syngenta) and digital agriculture/remote-sensing services (Gamaya). He is passionate about innovation and sustainable agriculture, always aiming to work in close collaboration with farmers at the center.

REGENERATIVE AGRICULTURE: INPUT TALKS

NIALL CURLEY

Senior Policy Advisor
COPA Cogeca

Regenerative agriculture from the farmers outlook: a welcome discussion that requires buy-in

ABSTRACT

How we manage our soils, how we manage our resources, and how we manage how we produce our food are at the heart of everything we as farmers and forest owners do. Sustainability is at the core of how we produce, and it must be clear that environmental sustainability is not the only show in town, but also economic sustainability and social sustainability. It is essential that all production models or solutions that are brought to farmers in order to improve soil, water, carbon issues are not just focused on getting to the end goal, but also the journey. Bringing farmers on board, ensuring that there is a genuine return on making changes, and ensuring that rural communities and regions are properly sustained. Genuine change comes from farmers on the ground, it is essential that any discussion on any models that affect how we produce with our soil, water, or inputs is not prescriptive, is not prohibitive, and is not dictative.

BIOGRAPHY

From a small family farm in the Irish Midlands, Niall obtained his bachelor's in history, political science and sociology from National University of Ireland, Galway. Following this, he graduated from a double master's degree in European governance in Masaryk University in Brno, Czech Republic, and in Utrecht University in the Netherlands. He currently works as the Policy Advisor coordinating the policies of biodiversity, soil, and water for the European farmer and agri-cooperative representative body, Copa Cogeca.

REGENERATIVE AGRICULTURE: INPUT TALKS

LUIS SANCHEZ ALVAREZ

Directorate General, Agriculture
EU Commission

Regenerative agriculture as part of the EU Mission A Soil Deal for Europe

ABSTRACT

Over 60% of European soils are unhealthy and scientific evidence shows that soils are further degrading due to unsustainable management. The EU Mission 'A Soil Deal for Europe' aims at establishing 100 living labs and lighthouses to lead the transition to healthy soil by 2030. Living labs and lighthouses are real-life sites for testing, demonstrating and upscaling of solutions for sustainable soil management and soil health regeneration.

BIOGRAPHY

Luis Sánchez Álvarez has been working at the European Commission since 2016, first at the General Directorate for Research and Innovation, where he participated in the design and implementation of the European Innovation Council (EIC) and was directly involved in the new EIC Fund, a venture capital fund created by the Commission to invest directly in highly innovative SMEs and startups. Most recently he has jointed the Directorate General for Agriculture.

Luis is a Doctor of Agricultural Engineering and has accumulated extensive experience in public policies in higher education, research, innovation, agribusiness and financial instruments. He is a civil servant of the Community of Madrid and has served as Director General in the Community of Madrid for almost 15 years in different areas (Agriculture and Rural Development, Industry, Madrid Institute for Agricultural and Food Research, Madrid Foundation, Agencia de University Quality).

NOTES

OPENING PLENARY: PETER WEHRHEIM

Head, Bioeconomy and Food Systems Unit
Directorate General for Research and Innovation
European Commission

The EU Mission a Soil Deal for Europe

ABSTRACT

Missions are a novelty of the EU research and innovation programme, Horizon Europe. They are a new way of bringing concrete solutions to some of our greatest challenges. Restoring and maintaining soil health is one of these major societal challenges.

The Mission "A Soil Deal for Europe" will support the transition towards healthy soils by 2030 by putting in place an effective network of 100 living labs and lighthouses in rural and urban areas. In addition to creating knowledge and solutions for soil health, the Mission will advance the development of a harmonised framework for soil monitoring in Europe and increase people's awareness on the vital importance of soils.

The Mission is firmly embedded in the wider EU policy frameworks: it will contribute to Europe's ambition to become the first climate-neutral continent by 2050 and is an integral part of a number of Green Deal strategies. Together with the EU Soil Strategy and the recently launched European Soil Observatory (EUSO), the Mission will carry out comprehensive actions for sustainable soil management and soil restoration across a range of land uses, e.g. agriculture, forestry, urban areas, natural/semi-natural areas.

BIOGRAPHY

Peter Wehrheim is Head of Unit for the "Bioeconomy and Food Systems" within the Directorate General for Research and Innovation of the European Commission in Brussels. Prior to this assignment, he worked for the European Commissioner for Agriculture and Rural Development, Phil Hogan. From 2010 to 2018 he was Head of Unit for Land Use and Climate Finance in DG Climate Action. Before 2004, Peter worked at the Universities of Bonn/DE, Maryland/US (with a Heisenberg scholarship of the German Research Foundation) and Kiel/DE. He received his doctoral degree in agricultural economics from the University of Giessen, Germany and comes from a vinery in southern Germany.

KEYNOTE: PETER SCHAD

Senior lecturer, Chair of Soil Science
Technical University of Munich

The soils of our planet – a fascinating resource

ABSTRACT

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 soils special 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 rule the soil formation. 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 decides 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. A nice example are paddy soils. Human activity may create completely new soils in urban, industrial, traffic, mining and military areas with new parent materials and specific soil-forming processes.

BIOGRAPHY

Peter Schad is a senior lecturer at the Chair of Soil Science of the Technical University of Munich (Germany). His scientific interest is the genesis and classification of the soils of the world from the permafrost regions and the deserts to the tropical forests and savannas. He was the chairman of the Working Group World Reference Base for Soil Resources (WRB) of the International Union of Soil Sciences (IUSS) from 2010 to 2022. Under his leadership two new editions of the international soil classification system WRB were published: the 3rd edition 2014 and the 4th edition 2022. In 2022, the IUSS awarded him the Guy Smith Medal for 'life-term outstanding contribution to the development of soil classification'. He is co-author of several scientific books, among them the book 'Soils of the World' (2022).

KEYNOTE:
SEBASTIAN DÖTTERL

Professor of Soil Resources
Department of Environmental Systems Science
ETH Zürich

Accelerated soil development: a key process to understand future biogeochemical cycles in arctic and alpine environments

ABSTRACT

Climate warming is transforming Arctic and Alpine environments at an unprecedented rate with strong effects on the cycling of carbon (C) and nutrients. Previously barren landscapes are "greening" as a result of longer snow-free periods and increases in plant growth. But although Arctic and Alpine environments are warming almost everywhere, patterns of greening and changes in the biosphere are highly diverse. A key to understanding the extent and patterns of greening of formerly sparsely vegetated environments will be to unravel the interactions between the biosphere and the role of soil genesis, which may be much faster than previously assumed in rapidly warming environments with poorly weathered soils.

Here, we propose an interdisciplinary approach to develop a deeper understanding of the evolutionary, ecological and biogeochemical processes underlying Arctic and Alpine greening. We show examples on changing soil-plant-microbiota interactions from the high-arctic Svalbard Archipelago, Northern Norway and the Alps across geoclimatic gradients. Our data illustrates that observed vegetation changes are not only tied to warming but to changes in the soil properties driven by soil weathering as well as shifts in soil microbial community functions. Furthermore, patterns of soil C storage and stabilization differed significantly with soil development across soil types and parent material and were much less dependent on plant C input than previously thought. As the investigated landscapes continue to change, we need to further our understanding of the biological and physical-chemical feedbacks associated with the ecosystem's transition into this novel state.

BIOGRAPHY

I am a Geographer with emphasis on Soils Science, Plant Ecology and Geomorphology. I did my PhD on the effects of soil erosion on soil carbon dynamics at different temporal and spatial scales. I apply both experimental and modeling approaches in my research. My interests focus on the connections and feedbacks between different environmental cycles in soils (C-N-P Dynamics) and how human activities and Global Change influence these cycles and soils as a resource.

ALYSSA DELUZ

PhD Student
University of Applied Sciences Western Switzerland (HES-SO HEPIA)

Cropping practices and soil quality as drivers of soil microbial communities

ABSTRACT

Soil microbial communities perform key functions for the soil-plant systems, such as nutrient cycling or pest and disease regulation. Agricultural management can strongly influence the soil microbiome either directly or indirectly. For instance, intensive tillage operation can affect mycorrhizal fungi by physically disrupting the hyphal network, and bacterial communities by modifying the availability of carbon sources and soil air-water equilibrium properties. Soil health and soil quality are considered equivalent concepts defined as the capacity of the soil to function, which includes the quality of the soil as habitat for living organisms. This function is closely linked to the pore network structure and resulting air-water equilibrium, and the organic carbon content as a proxy for the available food. Many soil indicators and quality thresholds to monitor soil health have been adopted or suggested in the literature. In Switzerland, quality thresholds of soil compaction and soil organic matter content have been commonly adopted for cropland sites. However, the relevance of these tools to assess the capacity of soil to harbour active and diverse soil microbial communities has not been thoroughly tested yet. The response of these indicators occur on very different time scales, from hour (e.g. structure and compaction) to decades (e.g. soil organic carbon content), though they interact and can be modulated by cropping practices. Moreover, as we begin to understand how agronomic management practices can influence soil microorganisms, the importance of the regional agronomic context and the local edaphic conditions needs to be taken into consideration.

This work aims to question on field the interplay between cropping practices, soil quality and soil microbial communities. To tackle this problem, a study was conducted in western Switzerland where 60 cropland fields were sampled to investigate the relationships between agricultural management, soil quality, and microbial communities. Based on previous research, the impact of cropping practices on soil health was assessed using semi-quantitative measurements to calculate various indicators such as tillage intensity and crop diversity. Soil quality was assessed by evaluating physical and chemical parameters, mainly soil organic carbon content, soil organic carbon forms, clay content, pH, and soil hydro-structural properties. The diversity of soil microbial communities was studied using metabarcoding of bacterial and fungal ribosomal markers. Microbial abundance and activity were captured at the community level using chloroform fumigation and basal respiration analysis, respectively.

The soil organic carbon content and the fine structural porosity accounting for air-water equilibrium in the soil are correlated and were shown to be promoted by soil regeneration practices such as green manure cover-crops. Going a step beyond bulk densities approaches, one of our main working hypotheses was that the fine structural porosity may govern the microbial abundance and diversity, while the coarser structural porosity, which is much more varying with time and practices were much less relevant properties for soil microbiota. This first working hypothesis is supported by the analysis of the interplay between soil hydro-structural properties, soil organic carbon content and microbial communities as observed in our sampling network, which will be presented in this communication.

BIOGRAPHY

I am doing a PhD thesis on the biological quality of agricultural soils. This project, funded by the Swiss Federal office for the Environment is a partnership between hepia (University of applied Science in Geneva), FiBL (Institute of Organic Agriculture) and ETH Zürich. I am mainly interested in the interplay between soil quality, agronomic management and soil microbial communities.

RICH STONE

Senior Policy Advisor
Department for the Environment, Food, and Rural Affairs (DEFRA), UK
rich.stone@defra.gov.uk

Current priorities and perspectives for soil health in the UK

ABSTRACT

In this presentation, Rich Stone from DEFRA will set out the UK Government's policy position for encouraging healthy, resilient soils that support production, nature and mitigate the impacts of climate change, e.g. flooding and drought. The discussion will cover England's new farming schemes and the commitments set out in the Environment Improvement Plan, published in January 2023, that aim to promote more sustainable soil management and integrated pest management approaches to minimise risks associated with pesticides and support sustainable agricultural productivity.

BIOGRAPHY

Rich is a Senior Policy Advisor for resilient soils in the Department for the Environment, Food, and Rural Affairs in the UK. The Resilient Soils team is responsible for ensuring soil is valued and sustainably managed so it is more resilient to the impacts of climate change, preventing further degradation, increasing biodiversity and enabling long term food security. Rich leads on a variety of projects related to soil health, including the development of national monitoring schemes.

PLENARY: KATIE FIELD

Professor of Plant-Soil Processes
Plants Photosynthesis and Soil
School of Biosciences, University of Sheffield

Climate and management impacts on mycorrhizal function in crops

ABSTRACT

Fungi and plants have engaged in intimate symbioses that, together with other soil microbes, have driven global terrestrial biogeochemical processes since plant terrestrialisation >500 million years ago. These associations, known as mycorrhizas, are usually considered to be nutritional mutualisms, whereby the plant benefits from greater access to soil nutrients in return for transfer of photosynthetic carbon to their mycorrhizal fungal partners. Enhanced access to soil nutrient pools is likely to have been critical for the success of the earliest plants on land and today forms the basis for the exploitation of soil fungi in sustainable approaches to food production and soil management.

The rise of non-vascular plants and the later evolution of plant roots and vasculature drove the long-term shift towards a high-oxygen, low-CO2 atmosphere and climate that eventually permitted the evolution of mammals and, ultimately, humans. Shifts in atmospheric CO2 concentration, together with biotic factors such as plant and fungal identity, have been shown to impact exchanges of carbon for nutrients between plants and their mycorrhizal fungi across plant and fungal lineages, including food crops. This has critical implications for application of mycorrhizal fungi for future sustainable agriculture in a rapidly changing climate. Our research has shown variable responsiveness to mycorrhizal fungi in terms of growth, functionality, and responsiveness to atmospheric CO2 concentrations across cereal crop cultivars. Crop access to soil nutrients can also be improved through application of wastewaters, slurries, and sludges as a means of recycling nutrients back into the soil. This approach has many advantages in terms of improving soil organic matter content, nutrient status, and water content and can be cost effective for farmers. However, application of these substances to agricultural soils can also be a source of emerging contamination, including human and animal-use pharmaceuticals. These contaminants are seldom removed by treatment prior to use, with unknown effects on soil microorganisms and plants. These findings show environmentally relevant concentrations of human- and animal-use pharmaceuticals can have dramatic impacts on mycorrhizal function and emphasises the need for regulation of human and animal-use pharmaceutical chemicals entering the soil environment.

Our research highlights the significant contribution of mycorrhizal fungi to sustainable crop production and identifies substantial potential for enhancing crop mycorrhizal receptivity, function, and responsiveness to rising atmospheric CO2 concentrations in the future. It emphasizes the importance of broadening our understanding and consideration of the impacts of sustainable soil management strategies on soil health and functionality to maximize the benefits of mycorrhizal associations in crop production.

BIOGRAPHY

I completed my PhD in environmental physiology in 2009 at the University of Sheffield before getting into mycorrhizas during my postdoctoral studies (2009-2015), also at Sheffield. I got my first academic post at the University of Leeds in 2015, moving there as a University Academic Fellow and becoming Professor in 2019. I moved back to the University of Sheffield this summer (2020) as Professor of Plant-Soil Processes.

FRANZ BENDER

Researcher, Plant-Soil Interactions,
Agroscope
Agroecology and Plant-Microbiome Interactions,
University of Zürich

Buried underpants as soil health indicator and awareness-raising tool using citizen science and ways to harness soil biological functions for agriculture

ABSTRACT

Soil life is a key driver of ecosystem functioning. However, studying soil organisms and their activity can be a tedious process, making large-scale investigations challenging. Moreover, awareness of soils as living systems among land managers and the wider society is often rare. We conducted a citizen science project systematically investigating soil biological activity and its major driving factors on 1000 sites across Switzerland. We adapted the idea of the so-called 'Soil Your Undies' campaigns for the first time in a scientifically structured way. We shipped 2000 standardized Cotton underpants and 12000 teabags to over 1000 citizen scientists (50% farmers and 50% private gardeners) from all parts of Switzerland. Participants buried underpants and teabags in soil and collected soil samples following standard protocols and entered site and management information into a specially designed App. After 1 and 2 months, underpants and teabags were retrieved, dried and returned to the lab. Underpants degradation was assessed using gravimetric and imaging methods and teabags were used to calculate the Tea Bag Index (TBI), an established method to assess soil decomposition processes. Soil samples were comprehensively analyzed.

Results showed that management practices and soil properties were the strongest factors explaining soil biological activity, while geographical patterns played only a limited role. Underpants degradation and TBI overall showed similar responses to different environmental and management variables but the TBI showed less variation and slightly stronger relationships. Underpants, however, provide an additional visual and haptic experience of living soils and serve particularly well for raising the awareness of soil biodiversity. We conclude that buried underpants can serve as an easy-to-use and fun soil health indicator for lay persons that allows rough estimations of soil health. The project aroused global media attention and communicated the importance of healthy and living soils across the planet.

Soil biological processes can be also harnessed to increase the sustainability of agricultural pro-duction, an approach termed soil ecological engineering. By introducing beneficial microorga-nisms, such as mycorrhizal fungi, into aagricultural soils, crop yields could be supported with less external inputs.

BIOGRAPHY

My research focuses on the ecosystem services provided by soil organisms. I am especially interested in finding ways to promote soil biological services and to integrate them into agricultural management schemes to enhance the sustainability of production. After working on the role of arbuscular mycorrhizal fungi in reducing nutrient losses from soil during my PhD at Agroscope and the University of Zürich, I relocated to the US for postdoctoral studies at UC Davis and UC Berkeley. There, I expanded my research focus on studying the effects of agricultural management on a range of soil organisms and the resulting consequences for ecosystem functioning. Since 2019 I am working as Team leader for soil ecological engineering in the research group Plant-Soil Interactions at Agroscope and the research group Agroecology and Plant-Microbiome interactions at the University of Zürich. There, I was recently leading a nationwide Citizen Science project investigating soil health across Switzerland.

ELENA BIAGI

Senior Researcher
Department of Civil, Chemical, Environmental
and Materials Engineering
University of Bologna

Compost-based soil amendments for a sustainable agriculture: linking soil biochemistry and microbiome responses

ABSTRACT

The rise of the word population and the consequent increasing demand for food production has to face the loss of soil fertility, mainly due to the low availability of soil organic carbon (SOC). In a perspective of sustainable production systems, the use of compost-based amendments obtained from urban biowastes could represents a solution for both soil restoration and wastes upcycling. Soil microbiome has been identified as key player on the overall functioning of the soil environment and it is of utmost importance to understand microbial response to restoration treatments along with induced variation in soil chemistry.

The aim of this study was to evaluate the effect of different compost-based amendments on soil biochemistry and to provide an insight on how long-term compost-based treatments can modify the network structure of soil bacterial and fungal communities. An experimental vineyard, planted at the University of Bologna (Italy) facility, was used as model, in which Sangiovese vine was planted on a clay-loam soil (Typic Udochrept) and coherently treated each year since plantation (2019). Four treatments were compared in a randomized block design with replicates: mineral fertilization, municipal organic waste compost (MOWC), sewage sludge compost (SSC), and sludge plasters (SP). Soil was collected in 2021 and analyzed for soil biochemical indicators (total and dissolved organic carbon, total and dissolved nitrogen, key enzymatic activities) and microbiome composition using both 16S rRNA and fungal ITS gene sequencing.

The microbial biodiversity of soil positively responded to MOWC and SSC treatment, whereas SP was the treatment mostly impacting the compositional structure, at both fungal and bacterial level, affecting the abundance of the dominant families. MOWC and SSC amendment were confirmed to provide the soil with alive bacterial and fungal inocula, whereas SP (obtained by alkaline hydrolysis) did not allow the recovery of an amendment-associated microbial community. Co-abundance networks based on Kendall correlation were built using both bacterial and fungal populations to explore variations induced by treatments and along with the changing soil chemical parameters. The core microbiome was composed by two distinct modules, including mixed bacterial and fungal families, connected by inverse correlations, whereas three ancillary modules showed sparse interconnection and correlation with chemical soil variables. The first core module was characterized by bacterial and fungal taxa (e.g. Pyrinomonadaceae, Gaiellaceae, and Mortierellaceae) that negatively correlated with the availability of carbon and nitrogen, and tended to decrease in amended samples with respect to controls and mineral fertilizer. By contrast, the second core module included families such as Xanthomonadaceae, Rhodanobacteraceae, Microscillaceae, Microscaceae and Ascodemidaceae, that increased in amended soil, especially when SP was used. Such taxa showed a positive correlation with soil features as total nitrogen and organic carbon, dissolved nitrogen and carbon, and phosphatase activity. In conclusion, the three types of compost-based amendments had effects on soil fertility and affected known keystone members of microbial communities, preserving or augmenting biodiversity. SP, while not significantly increasing biodiversity, was the most impacting treatment at compositional level as well as the one mostly affecting the network topology. The experimental vineyard will allow in the next years to connect such soil microbial community modifications to the vines' health as well as to the quality and features of the final product.

BIOGRAPHY

Elena Biagi holds a PhD in Applied Biocatalysis and Industrial Biotechnology. Her current main research interests reside in environmental microbiology, in particular in terms of compositional and functional characterization of environmental microbial communities involved in processes of interest (i.e. bioremediation and soil restoration). She acted as Scientific Project manager for a EU funded H2020 project (CIRCLES) and is now involved in other HORIZON EU projects that focuses on increase of soil productivity (TRIBIOME) and bioremediation of industrially polluted soil (NYMPHE). She published 90 articles in international scientific journals with >7000 citations (Scopus H-index, 39).

FLASH POSTER SESSION PRESENTED BY SYNGENTA

BEN OYSERMAN

AgroEcosystem Technical Manager
Syngenta

Profiling the impact of crop protection products on mycorrhizae

ABSTRACT

As the demand for food production increases globally, there is a growing need for effective crop protection products that can support sustainable agriculture. However, the impact of these products on non-target organisms such as mycorrhizal fungi is often overlooked. Mycorrhizal fungi play a crucial role in plant growth and nutrient uptake, making them a critical component in agricultural systems. Therefore, testing the compatibility of crop protection products on mycorrhizal fungi is essential to ensure their effectiveness and sustainability. From the industry perspective, testing the compatibility of crop protection products on mycorrhizal fungi is becoming an increasing priority. This approach can help to identify compounds that are effective against pests and diseases while supporting sustainable agriculture. Furthermore, compatibility testing can identify how compounds may be used responsibility. Thus, it is necessary to develop a testing platform for evaluating the compatibility of crop protection products on mycorrhizal fungi. The mycorrhizal life cycle is complex. Important steps in that cycle include spore germination and colonization, but also includes emergent functions such as the beneficial response observed in the crop. To evaluate the compatibility of crop protection products on mycorrhizal fungi, it is important to consider each of these aspects. Furthermore, such a testing platform should also consider the diversity of soil environments, mycorrhizal fungi, and crops. Here we present the progress and approaches we are taking to build such a mycorrhizal testing platform. We highlight some of our early successes and challenges and present a path forward to incorporate mycorrhizal compatibility testing as a soil health priority.

BIOGRAPHY

Dr. Oyserman is a Syngenta scientist investigating Soil Health. A focus of his research is the microbiome, plant-microbe interactions, and the impact of chemistries on the ecology of symbiosis.

FLASH POSTER SESSION

STEPHANIE LUTZ

Team Leader in Rhizosphere Ecology
Plant-Soil Interactions Group
Agroscope

To inoculate or not to inoculate: predicting the effect of field inoculations with arbuscular mycorrhizal fungi on maize yield

ABSTRACT

The global demand for food is continuously increasing as a result of population growth. However, higher crop yields often come at the expense of the environment. Alternative solutions to mineral fertilizers and pesticides that reduce the environmental footprint of agricultural production are urgently needed. Arbuscular mycorrhizal fungi (AMF) can enhance plant nutrient uptake, decrease the incidence of plant diseases and reduce nutrient losses from soil; yet, large-scale field inoculation trials with AMF are missing, and so far, the success of inoculating AMF in agricultural fields remains unpredictable due to high context-dependency. Here, we conducted inoculation experiments with AMF in 54 arable fields and investigated the effect of AMF inoculation on maize yield. AMF significantly improved the yield in a quarter of all fields (12 to 40% increase) while in two fields a significant growth reduction was found (12% decrease). In order to assess the factors explaining inoculation success, a total of 52 physico-chemical soil parameters were analysed in combination with PacBio sequencing of the soil and root microbiome. As a result, we could successfully predict 86% of the variation in plant growth response to inoculation. The abundance of pathogenic fungi, rather than nutrient availability, best predicted (36%) AMF inoculation success. With this work we were able to show that AMF have the potential to contribute to pathobiome management and possibly decrease the use of synthetic fungicides. Our results will help to better predict successful AMF inoculations in fields and thus increase the profitability of microbiome engineering as a tool for sustainable agricultural management.

BIOGRAPHY

Stefanie Lutz is a microbial ecologist and team leader in Rhizosphere Ecology in the Plant-Soil Interactions Group at Agroscope. Her work focuses on harnessing plant-beneficial soil and root microbiomes through indirect (identification and promotion of favourable management practices) or direct (inoculation of beneficial organisms) approaches and how we can exploit them to reduce the need for synthetic pesticides and fertilisers. She also explores the context-dependencies of field inoculations with arbuscular mycorrhizal fungi, the predictability of inoculation success and how we can harness the full potential of the mycorrhizal symbiosis to improve agricultural sustainability and productivity.

FLASH POSTER SESSION

EMILY DURANT

PhD Student
University of Sheffield

Impacts of veterinary pharmaceuticals on plant-mycorrhizal symbioses in the environment on soil nitrogen mineralization and plant productivity

ABSTRACT

In the past 20 years, there has been increasing research interest in the inadvertent contamination of pharmaceuticals and personal care products (PPCPs) in the environment, including veterinary medicinal products (VMPs). Many of these pharmaceuticals are excreted, exist in manures, and can go on to contaminate soils through the application of manures as fertilisers in food production systems. Some VMPs have been shown to accumulate in plants and negatively impact plant health. Similar to VMPs, human-use PPCPs can contaminate soils through biosolid application in the agro-environment. Both manure and biosolid application to soils are used to supplement plant nutrient availability and improve soil health by bettering the physical properties of soil and supporting the soil microbial population, such as arbuscular mycorrhizal fungi (AMF). This can result in a switch from conventional agriculture practices, such as relying on chemical fertilisers, to sustainable/regenerative agriculture practices.

AMF are a group of symbiotic fungi that exist almost ubiquitously in soils and form symbiotic relationships with most plant roots. AMF generally impart nutritional and non-nutritional benefits on their host plants. Nutritionally, AMF transfer fungal-acquired nitrogen and phosphorus to plants and, in return, plants provide photosynthetically fixed carbon to AMF. Non-nutritionally, AMF can enhance soil water holding capability, improve soil structure, increase plant abiotic and biotic stress protection, and more. Because of their role in promoting host plant access to soil nutrients, there has been increased interest and practice in utilising AMF in agricultural and horticultural scenarios to reduce the need for artificial fertiliser inputs while maintaining or even improving crop yields. Exploitation of AMF or deployment of soil management strategies to promote AMF communities and preservation of mycorrhizal networks in the soils represents a potential pathway to sustainably intensify food production in agricultural settings.

Artificial fertilisers are reliant on energy-intensive production processes and/or finite natural raw resources and their use can negatively impact soil health, including a decrease in soil organic matter, a decline in soil microbial populations and their function, and decreased nutritional content of soil. Replacements for artificial fertilisers include organic-based fertilisers, such as manures and biosolids which can be applied to soils. However, PPCPs are present in manure and biosolids and can have non-intended negative effects on soil health, such as impacting AMF.

In previous research, we found human-use antifungal azole fungicides greatly reduce P nutrient exchange from AMF to spring onion and lettuce and diminish the mycorrhizal network at environmentally relevant concentrations. Therefore, it is likely that certain VMPs present in soils following manure application can negatively impact the AMF-plant symbiosis. Here, we applied three VMPs (doxycycline, flubendazole, and sulfamethoxazole) at environmentally relevant concentrations to AMF-dwarf runner bean systems. Doxycycline and sulfamethoxazole are antibiotics, whereas flubendazole is an anthelmintic. Doxycycline has previously been found to decrease AMF colonization of plant roots, decrease network size, and decrease spore production. Flubendazole and sulfamethoxazole were used since they are azoles and it is known that other azoles (antifungal azoles) can negatively impact AMF. Additionally, sulfamethoxazole was also found to decrease network size and decrease spore production. To investigate the effect of the three VMPs on AMF structure and function, we tracked nutrient transfer using radio- and stable-isotopes, 33P, 15N, and 14C and assessed impacts on the soil microbiome community composition.

BIOGRAPHY

I am a first year NERC ECORISC PhD student at the University of Sheffield. My work focuses on arbuscular mycorrhizal (AM) community composition, structure, and function (e.g., nutrient transfer). I am particularly interested in how pharmaceuticals, inadvertently introduced into the agro-environment, impact these aspects of the AM symbiosis. Previously, I found that human-use antifungal pharmaceuticals, which enter soils through biosolid application, impair nutrient transfer between AM fungi and crop plants (Durant, et al., in prep). Now, I am shifting my focus onto various veterinary pharmaceuticals, introduced to soils following manure application, and how they impact the community composition, structure, and function of AM fungi.

FLASH POSTER SESSION

KLAUDIA DEBIEC-ANDRZEJEWSKA

Group leader, Agricultural Microbiology
University of Warsaw

Siderophores-based biofertilizers as a valuable complement/alternative to chemical fertilizers, soil regenerators and plants' biostimulants

ABSTRACT

The demand for innovative (bio) fertilizers is constantly growing in modern agriculture, due to the search for more sustainable ways of growing plants and the rising costs of conventional fertilization techniques. One way to create new valuable products is to use the potential of microorganisms to develop new, more environment-aware fertilizers. Besides the utilization of live bacterial cells in agriculture, also fertilizers based on produced by microorganisms metabolites could be an efficient plant-growth promoting agent. The valuable advantage of soil supplementation with microbial metabolites over cells application is the elimination of risks related to low activity and/or survivability of introduced microbes. Excellent examples of microbial-origin metabolites potentially useful in agriculture are various chelating agents, such as siderophores and organic acids, which play a key role in nutrient acquisition by bacteria. Properties exhibited by these compounds could be also used for enhancing the chemical and biological quality of the soil. Due to the creation of complex compounds with nutrients, chelating agents increase their bioavailability in soil, which allows for wider utilization of soil's natural nutritional potential. Also, used as mineral fertilizers additive, chelating agents enhance supplementation efficiency in plants. Containing various easy-accessible carbon and nitrogen sources, metabolites are not only beneficial for plants, but also boost microbial life in the soil, including numerous plant-growth-promoting bacteria groups, which also indirectly increase the bioavailability of nutrients.

In this study, we present the strategy used to develop biocomponents containing chelating agents of microbiological origin (biochelators), which are used in the design of innovative liquid bio-fertilizers. Among the studied biochelators are siderophores and accompanying metabolites increasing the bioavailability of macro- (P, K) and micronutrients (Fe, Zn, Cu). As an effective producer of biochelators, the psychrotolerant Antarctic bacterium Pseudomonas sp. ANT_H12B was used. At first, detailed genomic and physiological characteristics of Pseudomonas sp. ANT_H12B was performed. Genomic analyses involved the identification of genes related to the siderophores production and other plants growth-promoting properties. Physiological characteristics, in turn, concerned the analysis of the metabolic potential of ANT_H12B to utilize various carbon, nitrogen, phosphorus and sulfur sources in order to increase the rate and reduce the costs of biochelators production. Furthermore, the quantitative and semi-qualitative analysis of siderophores accompanying metabolites (SAM) was performed using GC/MS. In the next step, the obtained and optimized biocomponents were assessed in terms of their influence on the biological and chemical quality of the soil, thanks to the study of changes in the abundance, quantity and activity of soil microorganisms as well as the bioavailability of nutrients. Finally, biochelators activity was validated for plant growth-promoting properties in germination and vegetation tests. Genomic analysis of Pseudomonas sp. ANT_H12B showed the presence of genes responsible for the production of siderophores (pyoverdine and achromobactine) as well as other plants growth-promoting properties (eg. IAA synthesis, organic acids production, proteolytic and cellulolytic properties). In silico analysis also showed the potential ability of ANT_H12B to use numerous C, N, P, and S sources, which was experimentally validated using the BIOLOG test. It confirmed the metabolism versatility of the strain and showed that ANT_H12B was able to use 99 of 190 tested carbon sources (52%), 94.74% of tested nitrogen sources (both organic and inorganic), 100% of sulfur and 93% of phosphorus sources. The versatility of ANT_H12B metabolism allowed for the design of novel media suitable for the efficient production of siderophores in the form of pyoverdine (223.50 – 512.60μM). Moreover, depending on the medium composition, the pH of microbial cultures (siderophores and SAM solutions) varied from acidic to alkaline. Quantitative and semi-qualitative analysis of SAM showed the ability of ANT_H12B strain to produce various organic acids, alcohols, fatty acids, sugars and esters that were beneficial for plants growth. The positive effect of siderophores and SAM on plants growth was confirmed in germination and vegetation tests using selected crop plants such as peas, tobacco, beetroot, radish and lettuce. The all obtained results allowed for the development of an effective strategy for the production of biocomponents that can be used for the production of innovative bio- fertilizers, fulfilling the potential of bacterial metabolites as important compounds in agricultural applications.
 Funding: Project No. LIDER/13/0051/L-11/19/NCBR/2020 funded by the National Center for Research and Development (Poland).

BIOGRAPHY

I am a group leader of Agricultural Microbiology in the Department of Geomicrobiology, Faculty of Biology, University of Warsaw, Poland. My scientific interests are related to the application of various groups of microorganisms to the regeneration of both agricultural and contaminated soils. In this field, I work on the improvement of the chemical, physical and (micro)biological quality of soil that directly affects plants' health. Among my special scientific interest are the very close relationships between microbes and plants in the particular stages of the biological development of plants as well as the various possibilities of plants' biofortification by microbial cells and/or their metabolites. My research are realized in the frame of internal (Poland) and international scientific grants in cooperation with Polish, Italian, Czech and Netherlands scientists.

FLASH POSTER SESSION

JUNWEI HU

PhD Student
University of Gent

Root traits explain multitrophic interactions of belowground microfauna on soil nitrogen mineralization and plant productivity

ABSTRACT

Both herbivorous and bacterivorous microfauna have been shown to influence root development, soil nitrogen (N) mineralization, and plant productivity. However, our knowledge of these effects is limited as multitrophic interactions remain largely unexplored. We investigated whether and how herbivorous nematodes (Pratylenchus zeae) and bacterivorous nematodes (Poikilolaimus oxycercus), alone and in combination, affect plant biomass (Lolium multiflorum) through root traits and/or soil N mineralization. Bacterivorous nematodes increased, whereas herbivorous nematodes decreased, plant productivity. We found that root trait coordination in response to soil microfauna was consistent with the concept of root economics space. The negative interaction between herbivorous and bacterivorous nematodes on plant productivity at high herbivorous nematode infestation could be explained by reduced N mineralization and variation in the root nitrogen concentration-root tissue density (RNC-RTD) axis aligned with increased herbivore severity. This study revealed that herbivorous and bacterivorous nematodes moderated each other's effect on plant productivity via root trait coordination and N mineralization, and suggests, for the first time, the value of the root economics space concept for interpreting phenotypic root plasticity and functioning in response to local biotic factors.

BIOGRAPHY

Junwei obtained a bachelor's degree in Agronomy (2010-2014) from China Agricultural University and subsequently he followed a master program of Crop Ecology and Farming Systems (2014-2016). He did his master thesis on improving the N use efficiency of oat with the integrated application of microbial fertilizer and organic manure. Since 2016, he has worked on his PhD project about the mechanisms and collective role of soil microfauna in soil nitrogen cycling, supervised by Prof. Stefaan De Neve and co-promotor Prof. Mesfin Tsegaye Gebremikael, and funded by the China Scholarship Council (CSC) and UGent.

NOTES

FLASH POSTER SESSION

MICHA WEHRLI

Masters Student
University of Aarhus

Further testing of the fungicide fluazinam: Effects on three non-target species

ABSTRACT

Plant Protection Products (PPP) are extensively applied chemicals, to protect crops against pests and are one of the primary pillars of high production modern age agriculture. However, PPPs applied in agriculture can have unintended toxic effects on non-target organisms. As a result, modern agriculture represents a constant struggle between chemical driven high yield of edible crops, and the challenge of sustainable production.

Due to the toxic nature of pesticides, are these substances subject to a risk assessment before they are authorized for the use as a PPP in agriculture. In Europe the risk assessment is performed by the European Food and Safety Authority and is mostly based on acute and chronic effects of single products on standard earthworms and collembolan species.

In this study we wanted to test the fungicide Fluazinam based on the lack of data on species not considered in the authorization and unbound values for the springtail Folsomia candida. In addition, there is some controversy, related to the high potential toxicity of Fluazinam to Eisenia fetida detected in a laboratory tests. Field studies, conducted as a result of this high E. fetida toxicity did not show any relevant effects. In consequence, Fluazinam was considered to have acceptable risk by the EFSA and the Canadian, Pest management regulatory agency. In contrary to the EFSA and the PMRA, the substance was banned in Norway, due to the high potential toxicity to earthworms.

In this study the aim was to generate further data on the ecotoxicity of Fluazinam by testing its effects on three species Folsomia candida, Folsomia fimetaria and Enchytraeus crypticus. Testing was carried out, under standard laboratory conditions, utilizing a LUFA 2.2 soil and OECD guidelines. Additionally, test concentrations were measured with a method developed at the Central Environmental Laboratory at École polytechnique fédérale de Lausanne using an LC-MS/MS system. Preliminary results found a higher sensitivity of the newly tested species. E. crypticus and F. fimetaria, with effects detected below the lowest relevant measured environmental concentration. The results of this study and the new values derived, might provide further evidence that, fluazinam might have an unacceptable risk and should be re-evaluated to detect a safe application pattern. The study also demonstrates that non-target species not routinely tested like F. fimetaria and E. crypticus can have a higher sensitivity to certain PPP.

BIOGRAPHY

Micha Wehrli holds a BSc in Life Sciences with a major in Environmental Technologies, FHNW. Currently, he is studying Environmental Sciences with a major in Ecotoxicology at University of Gothenburg. He is investigating the effects of elevated temperatures on springtails, exposed to the fungicide fluazinam in his master‘s thesis at University of Aarhus.

FLASH POSTER SESSION

JAVIER MEYER

Chief Management Officer
Aqua4D

Restoring soil health through irrigation technology

ABSTRACT

AQUA4D irrigation technology helps alleviate some of the biggest issues the planet faces: water stress, soil degradation, and food security. It's all thanks to innovative water treatment which subtly alters irrigation water and the minerals within. Soil salinity often comes hand in-hand with drought conditions, and until now the most common solution has been water-intensive flushing – wasting precious resources where most needed. AQUA4D is the only technology which manages salinity while using less water in the process, and without consumables associated with technologies like reverse osmosis. Since 2004, growers in 45 countries have benefited, increasing their yields and output quality while minimizing resource input and solving long-standing salinity issues.

Minerals present in the water are efficiently dissolved by AQUA4D treatment, leaching salts below the root zone so they no longer crystallize. Soil health is improved and plants can flourish to their full potential. Continued irrigation with saline water is even possible, without requiring energy-intensive desalination or flushing. The same effect on minerals mean nutrients can be better absorbed by plants, and up to 20% less fertilizer need be applied. Lastly, as the technology reduces the size of water clusters while increasing soil porosity, soils stay moist for longer and irrigation frequency can be reduced by around 30%.

Over 20 years, this technology has been verified by dozens of scientific studies globally. Landmark research in the Jordan Valley observed continued irrigation of crops with saline water yet 37% higher yields, while a California State University study verified this in a lab setting, showing that AQUA4D leached 148% more salt compared with Control. A study at INRAE (France) proved changes in soil micro- and macrostructure, explaining both the efficient lixiviation and soil moisture effects observed by many growers. Most recently, research by INACAP (Chile) has proven significant reductions in chlorine and boron, reducing salinity conditions while saving ~30% water use. On a commercial level, after suffering years of salinity issues, Brazil's largest melon producer was able to return to two cycles on the same land while also increasing export quality and production by 17%. Additionally, an avocado grower in Peru conducted a side-by-side study of AQUA4D and reverse osmosis (RO). AQUA4D achieved the same salt leaching result while consuming 3000x less electricity, and without taking out or adding anything to the water.

This technology is supported by the Swiss Confederation, the Swiss Climate Foundation, and Solar Impulse Foundation among others. AQUA4D has also received grants as part of the EU's Horizon 2020 program, to expand the technology for pivot irrigation, with the significant land regeneration this would entail.

Irrigation with AQUA4D® is part of a new regenerative approach to agriculture, ensuring greater output with reduced inputs while allowing continued production on degraded lands. With the FAO estimating that soil salinization takes up to 1.5 million ha of farmland per year out of production, upscaled use of this technology would be a sustainable solution to the restoration of agricultural lands and wider food security.

BIOGRAPHY

Inspired by ideas and projects focused on the circular economy, Javier Meyer's career has spanned several continents connecting like-minded people and projects adding value to companies with sustainable impacts. With a LL.M. in international trade & affairs and PhD studies in marketing strategy, he is currently CMO at AQUA4D, a Swiss cleantech company that delivers benefits in soil restoration and water efficiency in agriculture.

FLASH POSTER SESSION

NEDAL A. T. AQEL

PhD Candidate, Soil Physics
ETH Zürich

Autoencoder neural network to monitor soil status and analyze the change in soil water dynamics

ABSTRACT

The content and energy of soil water are crucial role in shaping the functionality of soil ecosystems. Soil water dynamics directly impact key ecological processes, including nutrient cycling, microbial activity, and plant growth. Soil water dynamics are a complex function of atmospheric boundary conditions and soil hydraulic properties. To capture variations in soil water dynamics, we present a novel approach utilizing an Autoencoder neural network. Our proposed method extracts an overarching feature that represents the dynamic behavior of soil-water interaction. This new feature is also linked to the dynamics of matric potential, which is highly influenced by seasonal hysteresis (i.e., the relationship between water content and matric potential changes with season). The feature value is thus an integrated measure of the soil capacity to respond to changes in atmospheric conditions and can thus be used as a new indicator for physical soil health. This innovative approach (i) provides a means to monitor changes in soil water dynamics, (ii) serves as a warning system for any change in the complex relationship between soil water content and matric potential, and (iii) enables improved assessment and management of soil health.

The autoencoder, consisting of an encoder and a decoder, is an unsupervised artificial neural network that learns how to efficiently compress input data into a meaningful representation and subsequently reconstruct the original data from this compressed form. By connecting the encoder and decoder, the autoencoder effectively captures important patterns and variations present in the data, enabling comprehensive analysis and interpretation. For this project, we use the autoencoder to compress the soil water content time series into one feature. The value of the feature represents an integral measure of the complex temporal variations in the water content. We then run the autoencoder for different series of years to understand the reason for the changes in the encoded representation over time. After evaluation, we conclude that autoencoder representation is closely linked to the dynamic relationship between water potential and water content which is much more complex than the water retention curve measured in the lab. An increased autoencoder value signifies a steeper slope for the curve (less drainage for decreasing matric potential), higher saturated water content, and greater seasonality in the soil (higher variations between water content in summer and winter for the same matric potential). We hypothesize that a pronounced seasonality is a measure of dynamic soil structure and its loss over time would indicate the loss of soil structural features.
In summary, understanding the connection between autoencoder representation and the relationship between water content and water potential provides valuable insights into essential factors for soil health. This knowledge can guide future research and practices aimed at improving the quantification of soil health, enhancing water availability, and promoting sustainable land management for a resilient and productive ecosystem.

The accuracy of the autoencoder in predicting water retention curves was examined in nine distinct sites within the Canton of Solothurn, Switzerland. The study‘s objective was to evaluate the autoencoder‘s ability to capture the complex relationship between water content and water potential at each site by analyzing daily variations in measured water status. The findings demonstrated the autoencoder‘s capability to predict the seasonal patterns of the water retention curve accurately. This highlights the autoencoder‘s potential as a valuable tool for accurately analyzing and interpreting soil water dynamics and guiding sustainable soil management practices. The application of autoencoder in analyzing changes in water content measured through Earth Observation (EO) methods will be explored. Various EO measurement options, including SMAP L4 and L3 products, SMOS product, and Sentinel data, are available for analysis. By comparing the results of the satellite data analysis with those obtained at the site-specific profile scale, we can determine the effectiveness of the autoencoder in capturing variations in the water retention curve in soil across different locations worldwide. When the results align consistently, it suggests the presence of a robust system capable of detecting changes in the water retention dynamics at any location globally.

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BIOGRAPHY

As a water resources engineer pursuing a PhD in soil physics, I aim to use AI and advanced technologies to understand how water interacts with soils and improve soil health monitoring. By integrating Earth Observation data, I aim to identify practical indicators of soil health that can be applied worldwide. Through my research, I aim to contribute to sustainable land management and environmental conservation.

MELANIA FIORE

PhD Student
Politecnico di Torino

Soil and climate change: the role of soil organic amendments in carbon sequestration

ABSTRACT

Soil degradation is one of the main environmental problems of nowadays, affecting most of the soils worldwide. Soil degradation is defined as a «change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries» and it results from numerous complex processes. Nowadays most soils are threatened by various risks, such as sealing, erosion, compaction, pollution, salinization, desertification, biodiversity and carbon loss. Healthy soils are essential for sustaining life on Earth since they provide numerous fundamental ecosystem services for human beings, e.g., producing food, storing and purifying water, ensuring nutrient cycling for crop productivity, capturing carbon from the atmosphere. It is imperative to maintain healthy soils and restore degraded ones, also considering that they are crucial for the achievement of many Sustainable Development Goals (SDG 2, 3, 6, 11, 12, 13, 15). Thus, it is not surprising that one of the European Missions is specifically assigned to Soil Health with the aim of addressing its main threats. Particular attention is paid to soils' ability of capturing and storing carbon. The natural carbon capture capacity of soils represents a valid ally to face climate change, and, at the same time, reveals how soil degradation fosters it. The degradation of one third of the world's soils has released up to 78 Gt of carbon into the atmosphere and the restoration of degraded soils can remove up to 63 Gt of carbon. An annual increase of 4% of the world soil surface C stocks would nearly compensate the annual CO2 increase of the atmosphere. So, restoring soils' health status and maintaining it could play a crucial role for addressing environmental problems in many ways.

A huge contribution can come from agricultural activities, which are interlinked with soil. For this reason, carbon sequestration by farmers ("carbon farming") is treated by many European policies (e.g., Farm to Fork Strategy, Common Agricultural Policy 2023-2027, EU Carbon Farming Initiative). In the published Handbook for carbon farming mechanisms in the EU, the European Commission identifies five main carbon farming practices: management of peatlands, agroforestry, maintenance and enhancement of soil organic carbon (SOC) on mineral soils, livestock and manure management, and nutrient management on croplands and grasslands. To incentivize the adoption of carbon farming practices by farmers, the European Commission also foresees the payment in the form of "carbon credits" for every ton of carbon sequestered with the adopted practices. To do so, the carbon sequestration must be measurable and validated. Concerning the enhancement of SOC, a wide range of management practices can be applied to benefit it. However, the C sequestration of C-rich organic amendments (e.g., compost and biochar) is controversial, because, considering the whole lifecycle, the net effect is highly uncertain with potential drawbacks for soil health and biodiversity. The aim of the present study is to investigate the C sequestration potential of the main organic amendments, i.e., digestate from anaerobic digestion, compost, and biochar, which will be also compared in terms of physic-chemical properties and effects on soils' characteristics. To this aim, it has been chosen to use the same input biomass, specifically the Organic Fraction of Municipal Solid Waste (OFMSW) with animal manure in 80:20 ratio, for every amendment and to test different configurations. The OFMSW undergoes different treatments: anaerobic digestion, composting, and pyrolysis. Then, biochar will be added during the anaerobic digestion and composting to evaluate its effects to the processes' performances, according to the most recent highlights of scientific research. Furthermore, part of the digestate will be, in its turn, composted and pyrolyzed. The obtained amendments will be characterized and tested in pot to evaluate their effects on soil properties and plants growth and the results will be used to model the long-term evolution of SOC stock.

BIOGRAPHY

I received my Bachelor's and Master's Degree in Chemical Engineering at Politecnico di Torino (Italy). I started to focus my work on environmental issues during the Master's Degree, graduating in 2021 with a Thesis committed to water microplastics pollution, which led me to my first scientific publication of a review paper. In 2022 I started the PhD in Chemical Engineering at Politecnico di Torino and in collaboration with Re Soil Foundation, focusing my research on soil ecosystem.

FLASH POSTER SESSION

CAROLINA CARDOSO LISBOA

Manager of Agriculture Innovation
Verra

Voluntary carbon standard program and methodology for soil carbon quantification

ABSTRACT

Verra's Verified Carbon Standard (VCS) Program leads the way in developing methodologies and other tools to unlock the carbon reduction potential of agriculture, forestry, and other land use (AFOLU) projects. The VM0042 Improved Agricultural Land Management (IALM) v.2.0 is the key VCS methodology for the agricultural sector. This methodology, accompanying module (VMD0053 Model Calibration, Validation, and Uncertainty Guidance for the Methodology for IALM, v2.0), and tool (Tool for Soil Sampling, Processing, and Analyzing Soil Organic Carbon Stock Changes, under development) provide specific guidelines to quantify and monitor emissions reductions and removals (ERR) in the context of soil carbon offset projects VM0042 set out a standardized framework for quantifying the greenhouse gas (GHG) emission reductions and soil organic carbon (SOC) removals resulting from adopting IALM practices. Such practices include but are not limited to reduced tillage and improvements in fertilizer application, biomass residue and water management, cash and cover crop planting and harvesting practices, agroforestry, and grazing practices.

To date, the Verra registry has 74 projects listed as under development under the first version VM0042 v.1.0, and many more are expected under the new version VM0042 v2.0. These projects are spread throughout different geographical locations, including Africa, Asia, Europe, Latin America, the Middle East, North America, and Oceania. Collectively, these projects could contribute 43,911,017 CO2e/yr (though note they still need to be validated to begin generating ERRs). These projections indicate the potential of agricultural soils to contribute to climate mitigation. In fact, according to the Intergovernmental Panel on Climate Change (IPCC, 2022), the global agriculture mitigation potential is estimated at 0.9 GtCO2e per year at a low price (< USD 20/t C). Assuming 1% adoption of IALM practices starting in 2024, this could represent approximately 54 MtCO2e by 2030.

Yet, beyond SOC contributions to climate mitigation, it is worth noting that SOC and soil health are interconnected. Thus, SOC is critical in enhancing soil fertility, nutrient cycling, microbial activity, soil structure, erosion control, and multiple other ecosystem services. Maintaining and improving soil health, including soil carbon levels, can benefit agricultural productivity, ecosystem resilience, and climate change mitigation and adaptation. In this regard, the voluntary carbon market plays a critical role as it can support soil health through various mechanisms and initiatives. Investing in projects adopting VM0042 can effectively catalyze finance toward activities that can indirectly promote soil health, enhance carbon offset projects' environmental and agricultural sustainability, and ultimately contribute to climate mitigation and adaptation while supporting the United Nations (UN) 2030 Agenda for Sustainable Development and the UN Decade on Ecosystem Restoration (2021-2030).

BIOGRAPHY

Manager of Agriculture Innovation at Verra, Carolina supports the Agriculture Innovation team in addressing agricultural sector opportunities in our VCS Program. She works with the Program Team and external stakeholders to assess scientific best practices related to cutting-edge MRV technologies and frameworks for GHG quantification in the agricultural sector.

FLASH POSTER SESSION

SARAH HOHLMANN

Product Specialist
Agilent

Evaluation of New Anion Exchange and Synthetic Carbon Sorbents for the Determination of PFAS in Solid Samples Following EPA Method 1633

ABSTRACT

This flash-poster presents an evaluation of Agilent PFAS Bond Elut WAX and Agilent Carbon S for the extraction and matrix cleanup of per- and polyfluoroalkyl substances (PFAS) in solid matrices following the protocols specified in United States Environmental Protection Agency (US EPA) draft method 1633 (December 2022). Results obtained in this study were comparable to results reported in the draft method for the single laboratory validation study. The overall average recovery accuracy of native PFAS and extracted internal standards from solid matrix was determined to be 98 ±2% in this study compared to 94 ±4% in the draft method (95% confidence level, 64 measurements). The overall precision was also comparable. For both data sets, the measurement precisions were well below 20%. For the draft method, the overall average RSD was 3.9 ±0.6%, and for this study, the overall average RSD was 3.8 ±0.6% (95% confidence level, 64 measurements). Results are shown in the MDL table, midlevel recovery accuracy and precision graphs, target matrix spike recovery, and matrix spiked extracted external standard recovery. These tables and graphs present the results of the Agilent method and the single lab validation results in the EPA method. It's very easy to see where the results of the two data sets differ and agree. The EPA has not published multilab validation results for method 1633 for soils yet, so acceptance limits are not yet established for the method.

US EPA draft method 1633 was developed to consolidate procedures for the extraction and quantitation of PFAS in aqueous (nonpotable water), solids (soil, biosolids, and sediment) and tissue samples. Principally, the method utilizes polymeric weak anion exchange (WAX) solid phase extraction (SPE) for the selective extraction of target analytes in addition to matrix removal using graphitized carbon black (GCB). The target analytes are extracted along with isotopically labeled standards followed by separation and detection using liquid chromatography/tandem quadrupole (LC/TQ) mass spectrometry. To date, the draft method contains validation results for solids based on a single laboratory study for a total of 40 target PFAS across nine compound classes. The draft method contains rigorous quality control procedures to ensure optimal data reliability. The requirements are described in Section 91 and include: the initial demonstration of precision, accuracy, and method detection limits; the recovery of extracted internal standards and non-extracted internal standards; method blank determination; instrument calibration verification and maintenance; laboratory duplicates; analysis of field replicates when necessary; and analysis of matrix spikes when necessary. The performance of the extraction and analysis procedures for solid matrices was verified following the draft method quality control protocols using Bond Elut PFAS WAX SPE cartridges, Carbon S (Figure 1) as a replacement for GCB, and the Agilent Infinity II 1290 LC and Agilent 6470B triple quadrupole LC/MS. The results were compared to the US EPA draft method 1633 for the single lab validation study.

BIOGRAPHY

Sarah Hohlmann is a Product Specialist for columns and consumables at Agilent Technologies. Based in southern Germany, she is responsible for supporting customers in South Germany and Switzerland, particularly in the area of Bio columns, GPC and PrepLC columns. The focus is on consulting, training and general support for Agilent customers.

PASCAL BOIVIN

Professor of Soil Science and Group Leader
HEPIA, HES-SO

Soil quality as driven by cropping practices under intensified agriculture in the north of France: large-scale on-farm study

ABSTRACT

The soil quality was assessed at field scale using a minimum set of indicators, namely soil or-ganic carbon content (SOC), SOC to clay ratio, soil pH, Visual Evaluation of Soil Structure (VESS) spade test and bioturbation. A soil health score ranging from A (best) to E (worst) was calculated based on these indicators. The cropping practices on the rotations were selected based on the results of (Dupla et al., 2022) in the south-western Switzerland. The following indi-cators were collected and averaged on the rotation length: crop diversity, soil tillage intensity rating (STIR), continuity of soil cover (in % of the year) estimated by remote sensing, fresh bio-mass restitution (including roots and residues from the main crops and the cover crop biomass) and farm manure supply. The yearly change of the SOC was estimated using the AMG model (Clivot et al., 2019; Levavasseur et al., 2020).

Most of the soils were of poor quality, with C to E health scores. They showed very low SOC content based on the structure vulnerability SOC:clay ratio thresholds (Johannes et al., 2017). We identified height cropping successions, namely vegetables, cereals, cereals with sugar beet or potatoes or vegetables, cereals with sugar beet and potatoes or legumes, and cereals with oil-seeds, respectively. The cropping practices indicators were growingly harmful to the soils, with larger duration of bare soil, larger STIR and smaller fresh biomass restitution, from pure cereals to cereals plus sugar beet, potatoes and vegetables. Farm manure was negligible in all systems due to the absence of livestock. However, compared to the differences between these cropping systems, the variability of each indicator in each system was very large, covering most of the possible range, which suggests that each system can be managed in a much sustainable way. The relationships between the cropping practices were close to those reported in (Dupla et al., 2022). The higher the STIR, the smaller the soil cover, and the fresh biomass residues. The fresh biomass returned to the soil was explained by crop yield and cover-crop biomass, howev-er the gap between the different farms was explained by the cover-crop strategy biomass and the soil cover. In all cases, some farms managed to maximize these parameters, which corre-sponded to the highest soil quality and / or highest SOC increase according to AMG simulation. Interestingly, the crop diversity was not positively related to the soil quality and SOC increase because the additional crops were soil impacting crops (e.g. sugar beet), with an increase in STIR and a decrease in soil cover.

This first step of this regional soil regeneration project allowed to show the high potential of soil sustainable management improvement based on soil cover continuity and fresh biomass re-turned to the soil with cover crops, and to detect the most sustainable options already applied by pioneers in each of the cropping systems. Together with previous studies, it showed that a lim-ited number of cropping practice indicators rather than the type of crops in the rotation allow to understand how to improve the cropped-soil quality.

BIOGRAPHY

Pascal Boivin is professor of Soil Science, and President of the European Confederation of Soil Science Societies. He is leading research in soil physics, on soil quality indicators, soil quality management, and regenerative agriculture. With his group, he is focusing on the impact of soil organic carbon and soil organic carbon forms on soil physical and biological quality, and on how farming practices influence soil quality and soil organic carbon content.

PLENARY:
MATTIAS RILLIG

Professor of Ecology
Institute of Biology, Freie Universität Berlin

Effects of multiple threats on soil processes and biodiversity

ABSTRACT

Soils face multiple concurrent environmental challenges, including from factors of global change. Even though we know of such effects, they are difficult to examine experimentally for a number of reasons. We have designed experiments that ask a simpler question, namely concerning the effect of the number of environmental factors on soil biodiversity and processes. This work is based on an experimental gradient in the number of factors. Several such experiments have shown that soils respond to an increasing number of factors with a clear trajectory of decreasing process rates and biodiversity. More recently, we have also been able to extract the signature of the number of factors from a global observational dataset, reinforcing the notion that we need to be concerned about the multitude of impacts that can challenge soil health.

BIOGRAPHY

Matthias Rillig is a soil ecologist interested in uncovering the effects of factors of global change on soil processes and biodiversity, with an organismal focus on fungi (including mycorrhizal fungi). Current research in his group addresses the role of multiple concurrent factors of global change on terrestrial ecosystems, and explores the use of soil fungi to address ecological principles. Many lab members work on microplastic effects in soils. Work takes place in agroecosystems, but also grasslands and other ecosystem types.

Matthias earned a PhD from University of California, Davis/ San Diego State University (1997). He has been a faculty member at University of Montana, and he is now a professor of ecology at the Institute of Biology at Freie Universität Berlin. Matthias is a member of the Academia Europaea (2022); the German National Academy of Sciences – Leopoldina (2021); a Fellow of the Ecological Society of America (2019); and has received a European Research Council (ERC) Advanced Grant (2015).

MATHIEU RENAUD

Soil Ecotoxicologist
Ecotox Center and EPF Lausanne

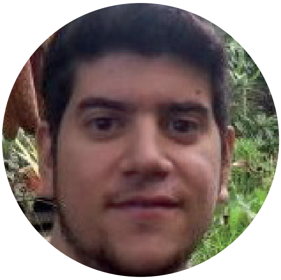
ConSoil project - developing a biomonitoring approach to evaluate the risk of Plant Protection Product residues to soil fertility in agricultural soils

ABSTRACT

Soils contain complex networks of organisms which provide ecological functions allowing the balance, maintenance and resilience of the soil ecosystem. In agricultural soils, the functions performed by soil organisms play a critical role in maintaining soil fertility. To maintain high productivity and to protect agricultural crops from pests, plant protection products (PPP) are applied, but may also have adverse effects which can disrupt soil functions and soil fertility. To avoid adverse effects of PPP on soil non-target organisms, a prospective risk assessment is performed prior to their (re-)authorization. However, PPP residues occur in soil as complex and persistent mixtures. For instance, synthetic PPP residues have been detected in agricultural soils in Switzerland even decades after transition to organic management. Therefore, a retrospective assessment for long-term effects of PPP residues needs to be implemented in Swiss agricultural soils. In Switzerland, the Swiss Federal Council adopted an Action Plan, aiming at reducing the risks of PPP by half by 2027 and promoting their sustainable use in soil. Measure 6.3.3.7 of the Action Plan, requires the development of a monitoring program for PPP residues in agricultural soils. The ConSoil project (EcotoxCentre and Envibiosoil) was mandated to develop a proposal for two of the objectives within this measure, develop (1) risk-based reference values for the assessment of PPP residues in soil, and (2) indicators for evaluating their effects on long-term soil fertility. In parallel, the Swiss Soil Monitoring Network (NABO) is developing a chemical monitoring for PPP residues in agricultural soils. For the first objective, a proposition for ecotoxicological risk-based reference values, called Soil Guideline Values (SGV), is under development. Based on a review of several soil regulatory frameworks, specific recommendations are provided on how to derive SGV with the aim of protecting relevant soil functions in agricultural systems in the long term. Some of the recommendations include assessing the reliability and relevance of chronic ecotoxicological data for soil organisms, the normalization of toxicity data to standard soil organic matter content, and the use, when possible, of ecosystem-relevant derivation methods to decrease the uncertainty of the hazard assessment. To address the combined toxicity of multiple PPP residues, it is envisioned to develop a concept for a mixture assessment in a further step. For the second objective, a toolbox of bioindicators to measure the long-term effects of PPP residues is under development. The selection of bioindicators consists of multiple steps. First, the actors (i.e. soil organisms) with a role in ecological soil functions supporting soil fertility are identified. Then, actors are ranked by their degree of connectiveness to different ecological processes and to the relative importance of ecosystem services for soil fertility, as perceived by different stakeholders. Bioindicator tools will be selected for the highest scoring actors, from available standardized guidelines or well-established test methods. The selection of the most appropriate methods will be performed in consultation with international experts for each key actor group, based on applicability, cost and quality of data generated for each method. The final toolbox aims to include both laboratory and field indicators. In risk assessment the combination of chemical, ecological and ecotoxicological data is known as a TRIAD approach and has been standardized for soil site specific risk assessment. The TRIAD approach can be used to integrate the chemical monitoring, the SGV and the bioindicator toolbox and provides a solid basis to evaluate the effects of PPP residues in the field. Since it is not possible to perform a TRIAD approach in all monitoring sites, an adapted TRIAD is proposed. SGV are compared to chemical monitoring data and serve as generic screening values to identify which sites need further assessment. Sites flagged for further assessment undergo detailed monitoring, where the generic SGV is refined based on specific site properties and the bioindicator toolbox is applied. Detailed monitoring should be conducted over multiple years (e.g., 5 years), to evaluate the long-term trends of PPP residues and their impact on bioindicators. Once the detailed monitoring is completed, an assessment on the long-term risk for soil fertility can be conducted. The information generated from the monitoring and on different sites can also be used as a feedback loop, to evaluate and calibrate the bioindicator toolbox as well as the SGV over time. The biomonitoring of PPP residues in agricultural soil is a complex and challenging topic, but the integrated approach proposed can help to get a better understanding of the environmental effects of PPP residues on soil organisms, responsible for maintaining soil fertility, and how these effects change over time.

BIOGRAPHY

I have a PhD from the University of Coimbra, Portugal in co-supervision with the University of Saskatchewan in Canada, where I studied the effects of metal mixtures on soil invertebrate communities and functioning. Since 2021, I am a soil ecotoxicologist at the Ecotox Centre, where I look to understand the effects of contaminants on soil organisms. In particular I focus on the testing, development and standardization of biological test methods for the soil compartment. Among other project I lead the ConSoil project which aims at proposing a biomonitoring approach, aimed at protecting long term soil fertility, for plant protection product residues in soil.



NIKOLAS CHRISTOS VAVLAS

Post Doctoral Researcher
Environmental Engineering
Wageningen University

Remote sensing of cover crop legacies on soil health and main crop N-uptake dynamics

ABSTRACT

Sustainable management of arable cropping systems requires insight into the temporal dynamics and spatial variation of crop performance to minimize nutrient losses and enable soil health-based precision agriculture. In arable systems, growing cover crops is a tool to promote soil health as they enable nutrient retention in autumn/winter and provide nutrients in spring/summer to the main crop upon cover crop mineralization by the soil biota. However, different cover crop monocultures and mixtures affect the soil biology and nutrient dynamics differentially due to the variation in quantity and quality of the plant material returned to the soil. To understand the legacy effects of cover crops on the main crop we need high resolution data of the crop responses to soil health conditions throughout the growing season. Remote sensing can provide such high-resolution data yet requires solid parameterization before it can be operationalized. Here we studied the temporal dynamics of soil nitrogen (N) availability and N uptake in barley in response to the soil legacy of different cover crops. We used high-resolution multispectral images of the main crop acquired from a Unmanned Aerial Vehicle (UAV), and in situ collected plant and soil parameters in a long-term field experiment with eight different cover crop treatments. The cover crop legacies significantly affected N uptake, biomass, and canopy chlorophyll content (CCC) in barley, with highest values in barley grown after vetch-radish or oat-radish and lowest in barley on fallow or oat legacy plots. The temporal dynamics of N-uptake throughout the barley growing season revealed that cover crop legacy effects became apparent/distinct by the end of stem elongation. This work demonstrates the potential of remote sensing to monitor and understand temporal and spatial variation of crop canopy traits in response to cover crop induced soil health legacies. This approach can contribute to more efficient N use by enabling fine-tuning of the quantity, timing, and location of fertilization.

BIOGRAPHY

Nikolaos Vavlas is an environmental engineer and modeller focusing on nature-based solutions for sustainable agriculture. As a post-doctoral researcher at Wageningen University, he works on soil health and the potential of remote sensing. His PhD at Rothamsted Research and Cranfield University (2017-2021) focused on satellite applications in agriculture aiming to provide crop productivity indicators. Since his master‘s diploma in environmental modelling at UCL (2015), Nikos has aimed to connect models and remote sensing-derived information to enable accurate monitoring of soil health dynamics under a GIS framework.

PLENARY:
GIULIA GREGORI

Head of Corporate Strategy Implementation &
Engagement, Novamont

Soil regeneration and circular bioeconomy

ABSTRACT

The bioeconomy, which has its roots in the soil, if declined in a circular logic and as a connection between different sectors, represents a key element to regenerate our soils, decreasing the use of non-renewable resources and maximising the efficiency and sustainability of renewable resources. An antidote to boost Europe‘s sustainability and competitiveness in the current economic, social and geopolitical context.

Implementing the circular bioeconomy toward a sustainable development requires a systemic and transformative redesign effort, overcoming silo logic typical of the linear economy. This new approach needs to be played out at local level, on agriculture, on integrated value chains, on the relationship between cities and food, on the eco-design of products, on interconnected infrastructures for the treatment of liquid and solid organic waste, and on the exploitation of waste into bioenergy and new bioproducts. We should start moving bioeconomy from a regulatory framework purely related to research and development towards a framework that can push this industry as a strategic element of the European industrial policy.

BIOGRAPHY

Catia Bastioli is a chemist, researcher and entrepreneur. She is CEO of Novamont, President of Terna Spa of the Kyoto Club Association and of the Italian Technological Cluster of Green Chemistry SPRING, and member of the Board of Directors of Fondazione Cariplo. She has been developing and field-studying the model of biorefineries integrated in the local areas, where the primary objective is an efficient use of resources and priority is given to high value-added products (bioplastics and biochemicals), short value-chains and a system-based economy. This represents a cultural (before than economical) development model, based on territorial regeneration that starts from decommissioned chemical sites and uses local biodiversity and scraps in order to give origin to renewable raw materials, capitalizing research and innovation and involving different stakeholders (institutions, research bodies, actors of the agricultural and industrial world). The innovative technologies developed for the bioplastics integrated supply-chain have led to the foundation and growth of a series of companies, that today form part of the Novamont Group. She has been a member of important EU working groups on climate change, environment and renewable raw materials, such as the European Union Bioeconomy Panel. Prime inventor of around 80 patent families in the sector of synthetic and natural polymers and transformation processes of renewable raw materials, she was awarded “European Inventor of the Year 2007” by the European Patent Office and the European Commission for her inventions related to starch-based bioplastics between 1991 and 2001.

PLENARY:
NIELS HALBERG

Director, Danish Centre for Food and Agriculture
Aarhus University

Living labs and soil needs assessments in support of EU Mission: A soil deal for Europe

ABSTRACT

The EC has launched a Mission, "A Soil Deal for Europe" to reverse negative trends in soil health across Europe. The aim is to lead the transition towards healthy soils in 2030 and is part of the EU Green Deal, a transition to overcome threats by climate change and environmental degradation. More specifically, the Mission focuses on eight objectives including reducing desertification, soil sealing and soil pollution, conserving soil organic carbon, improving soil structure and biodiversity, preventing erosion and enhancing restoration. Moreover, the Mission will support initiatives to improve soil literacy in society. The main tool to create the necessary momentum is the establishment of 100 Living Labs (LLs) and Lighthouses across all land uses: agricultural, forestry, natural, industrial and urban sites. LLs are place-based, user-centered and transdisciplinary organizations of multiple stakeholders in R&I activities in real-life settings and each with several sites such as farms or forests in a region.

So, which specific soil challenges should the LLs in different regions focus on? As part of the negotiations foreseen between stakeholders in each LL, Prepsoil proposes a concept for clarifying pertinent "soil needs" based on focus groups and interviews with the land users and managers themselves. As a starting point, Prepsoil has performed Soil Needs Assessments in 21 regions across several land use types and soil types.

BIOGRAPHY

Niels Halberg is Director of the Danish Centre for Food and Agriculture (DCA), Aarhus University (AU). He is responsible for coordination and organisation of the approximately 30M Euro annual contract with the Ministry for Food and Agriculture on science-based policy advice and industry collaboration. Niels chairs the Board of Programme managers in EJP Soil, and is the coordinator of two CSAs (Prepsoil.eu and nati00ns.eu) supporting the EU Soil Health Mission. For 25 years, he has been conducting research in organic agriculture, cropping and dairy systems, agroecology and food systems, environmental assessment of farming systems and food (LCA), and value chains. He was the coordinator of the deepfrontier (au.dk) project researching deep root development from 2014-2020. His broad experience includes international research collaborations in Europe, Asia, East Africa and Brazil.

MISATO TODA

Scientific Associate, Institute for Geomatics
Fachhochschule Nordwestschweiz (FHNW)

Microplastic pollution in agricultural soil: application of hyperspectral imaging and artificial neural networks

ABSTRACT

Plastic pollution resulting from agricultural practices poses a significant threat to soil health. Previous research indicates that plastic debris in soil, especially small particles known as microplastics (MPs) with a particle size of less than 5 mm, can have adverse effects on soil organisms. MPs accumulated in soil can be leached into groundwater systems, endangering our water resources. In agricultural soils, potential sources of MPs include plastic products such as mulching film, application of organic fertilizers, irrigation systems, and atmospheric deposition. In earlier work, we analyzed organic fertilizers from 22 different composting plants and found that on average, these fertilizers contained between 0.035–2 g of plastic per kg. The next step would be to examine field conditions and to what extent plastic debris in organic fertilizers contributes to MP pollution in agricultural soil.

To date, the occurrence of MP in soil environments is primarily investigated through chemical extraction followed by polymer identification with fourier transform infrared spectroscopy (FTIR). However, this method is time-consuming and not suitable for large-scale evaluations such as soil health monitoring. Hyperspectral imaging (HI) is a promising tool for automating rapid monitoring of plastics in complex matrix such as organic fertilizers and soil. The combination bands in the near infrared region enable to identify chemical composition of plastics. Some recent studies further combine HI with deep machine learning for soil MPs detection, nevertheless, comparative research is scarce.

In this study, we examined the distribution of MPs from topsoil to subsoil in an agricultural field where organic fertilizer has been applied repeatedly. Additionally, we tested the possible application of HI technology coupled with a machine learning algorithm for a rapid quantification of MPs. Soil samples were collected in October 2022 from a farmland in Switzerland, and a total of 90 cores were collected at 30 sampling points, at 3 different depths (0–30 cm, 30–60 cm, and 60–90 cm). Soils were dried at 40°C and sieved with 2 mm sieve for downstream analysis. Approximately 5 g of subsample was used for a traditional extraction method followed by polymer identification by FTIR spectroscopy (Frontier, Perkin Elmer, U.S.A) to ensure in-depth analysis. For HI analysis, about 15 g of soil sample were scanned by a Specim FX17 hyperspectral camera (Specim, Spectral Imaging Ltd., Finland) with spectral wavelength of 900–1700 nm and a total of 224 spectral bands. Then, the collected HI data was analyzed with spectral libraries and machine learning algorithms in a python code.

The initial results showed that the HI system could distinguish aged plastic debris (about 4–14 mm in size) from soil background. However, no smaller particles were detected, meaning that the HI system would be a powerful tool to quantify rather bigger MP particles. Future analysis by chemical extraction method can be used to train our machine learning algorithms to improve identification accuracy of the HI system. Collectively, we aim to provide further information about the extent to which organic fertilizer is responsible for MP pollution in the investigated field, as well as a possible application of HI system for rapid MP detection in soil. This could help us to identify pollution hotspots and establish more effective and faster soil monitoring systems.

BIOGRAPHY

I am a scientific associate at FHNW working on a project about microplastic in agricultural soil. Previously, I obtained my PhD in Agroecology and Plant-Microbiome Interactions at the University of Zurich. My research topics include (1) interactions among biodiversity, ecosystem functions/services, and sustainable resource use, particularly nitrogen, (2) biogeochemistry of agricultural land, i.e., the response of soil and ecosystem nutrients dynamics to management regimes, and (3) the fluxes and residence time of microplastic in soil and its interaction with soil properties.

PLENARY:

NATALIA RODRIGUEZ EUGENIO

Land and Water Officer
Food and Agriculture Organization (FAO)
United Nations

Global fertilizer crisis: challenges and opportunities for boosting soil health

ABSTRACT

The world is facing a food security crisis of historic proportions. Countries are already reeling from increased poverty, hunger, and malnutrition as a result of COVID-19, climate shocks, and face further suffering from ongoing geopolitical conflicts. The COVID-19 pandemic led to disruptions in the supply of agricultural commodities and increased transportation costs that have not yet been fully restored. The war in Ukraine is pushing global food prices and costs of fertilizer and energy up. These two unexpected drivers of the economic slowdown have added to the short-, medium- and long-term impact of changing climatic patterns. These global challenges jeopardize food availability and access to food in local markets, mainly in developing countries, where billions of people still face pervasive poverty, hunger and malnutrition.

Soils are the vital resource for farmers to produce 95 percent of our food. Soil fertility is inherently associated with agricultural production and, therefore, crucial to food security and nutrition, and to fight against poverty. Over the past decades, global food production has kept pace with a rapidly growing population at a high environmental cost. But now the world is looking for durable and effective options to tackle global challenges. Sustainable agricultural practices lead to direct improvements in the state of soil, land, and water, and generate ecosystem benefits.

BIOGRAPHY

Natalia Rodríguez Eugenio, a Spanish national living in Rome, is a Land and Water Officer at the Food and Agriculture Organization of the United Nations and a member of the Secretariat of the Global Soil Partnership. She holds a Master's degree in Sustainable Soil Management and Protection and a PhD in Soil Science. After more than 15 years of work experience in different dimensions of sustainable soil management, Natalia currently coordinates the implementation of activities and projects on soil degradation, soil remediation and governance, provides technical support in the project cycle and is the regional facilitator of the European and Eurasian Soil Partnerships. Before joining FAO, she worked as a soil contamination expert at the Joint Research Centre of the European Commission, where she published a major report on the State of Soil Contamination in Europe and as a soil expert in QC/QA and GIS where she developed the soil mapping of Ecuador. After publishing a book and several scientific articles on the subject, Natalia was the main author and coordinator of the Global Soil Contamination Assessment report, a FAO flagship publication collectively elaborated by more than 200 experts.


Agroscope is the Swiss centre of excellence for the research in agriculture and food sector
Over 1100 employees conduct research in more than 100 projects on the following six main priorities:
Agriculture in a Changing Climate
Protecting Natural Resources
Agroecological Production Systems
Cost-Efficient and Species-Appropriate Animal Husbandry
Sustainable and Healthy Food
Competitive Food Production

JENS LEIFELD

Head, Climate and Agriculture Research Group
Agroscope

The climate challenge of managing organic soils

ABSTRACT

Organic soils from peatlands managed for agriculture or forestry are among the largest greenhouse gas (GHG) sources in the agricultural and land-use sector. In addition, their drainage induces soil degradation and loss. With drainage, CH4 emissions typically decline whereas particularly CO2, and to a smaller extent N2O, strongly increase. In Europe, many countries have recognized these threats and measures and policies to reduce management intensity of these soils or return them to natural conditions via increasing water table depths are under way. In light of the need for production, however, agricultural use is expected to continue in many places. In this presentation, the magnitude of the GHG source, management effects, and possible alternative ways of using these soils are discussed. For the latter, results from experiments with mineral soil cover and rice cropping in Switzerland will be presented. Furthermore, ways to assess the development in GHG emissions over time as induced by different management of organic soils will be addressed.

BIOGRAPHY

Jens Leifeld is Head of the research group Climate and Agriculture at Agroscope, Switzerland. His research focuses on carbon sequestration and greenhouse gas emissions from organic soils.

WORKSHOP ON SOIL HEALTH: FROM PRACTICAL ISSUES TO INDICATORS

Organized by:

BETTINA HITZFELD

Leader, Soil and Biotechnology Division
Federal Office for the Environment (FOEN)

ALEXANDER WISSEMEIER

Adjunct Professor, Institute for Botany
Leibniz Universität Hannover

NATALIA RODRIGUEZ EUGENIO

Land and Water Officer
Food and Agriculture Organization (FAO)
United Nations

THREATS TO SOIL HEALTH

What are the biggest threats to soil health?

Ranking Exercise – 10 Global Soil Threats:

- Soil erosion
- Soil organic carbon loss
- Soil nutrient imbalance
- Soil salinization
- Soil contamination
- Soil acidification
- Loss of soil biodiversity
- Soil sealing
- Soil compaction
- Waterlogging

DEFINITION OF SOIL HEALTH

What is healthy soil for you? Your definition of a healthy soil?

Enter your definition. Participants will vote the definitions later.

CLAUDIA PREININGER

Senior Researcher
Austrian Institute of Technology

NETmicroplastic in agricultural soil and its impact on soil properties

ABSTRACT

Soil fertility is key for sustained plant growth and consistently high crop yields. Microplastic introduced to agricultural soil through mulching films, compost products, polymers and additives of fertilizers, and littering has potentially negative impacts on physico-chemical soil properties, soil ecology and agricultural production. Due to its small particle size, large specific surface area, and strong hydrophobicity, microplastic can adsorb to other soil pollutants (e.g., pesticides, antibiotics, plasticizers) and microorganisms. Microplastic is reported to affect soil properties depending mainly on soil type and microplastic characteristics. It is taken up by soil animals via feeding pathways, and over time is prone to forming nano plastic that migrates and accumulates in plants, thereby entering the food chain and potentially causing harm to humans. Presently, information is limited about microplastic as influencing factor of soil physical properties such as water holding capacity and soil processes like aggregation, besides its potential impact on the performance and composition of soil microbial communities and soil fauna and flora. Even less is known about the migration, degradation and mode of degradation of microplastic in soil.

In NETmicroplastic (www.net-microplastic.eu) we aim to create a sustainable network of actors and stakeholders, including farmers, industry, policy makers, researchers, the educational sector and the general public, to tackle the many knowledge gaps concerning microplastic in agricultural soil, including its role in preserving soil fertility. We address, among others, the mechanisms of microplastic interaction with soil microbes and microbial degradation processes of microplastic; effects of microplastic on soil and plants, and perform impact studies of microplastic properties (size, shape) on soil properties (e.g., water holding capacity). We aim to support innovative technological solutions and foster policy making to oppose plastic pollution in soil and terrestrial environments, with a special focus on fruit and wine growing. This will result in (i) a deeper understanding of microplastic in agricultural soil, (ii) the generation of science- and evidence-based impact data, and (iii) the formulation of novel soil management practices to protect and improve soils for a more sustainable agriculture.

NETmicroplastic consists of 12 core network partners from 4 European countries representing all relevant stakeholder groups, with AIT Austrian Institute of Technology as the lead partner. Three thematic groups, technology (bioplastics), environment (impact assessment) and education (school projects) help to remove barriers and will link the different impact fields in interdisciplinary teamwork and transdisciplinary collaboration, expanding from local to national and European level. This will finally produce reliable and socially robust knowledge for multiple sectors and stakeholder groups. Thus, we aim to jointly obtain a growing understanding of the role of microplastic in soil health and support the development of management strategies that protect soil fertility, ensure nutrient and water supply, and prevent soil erosion.

BIOGRAPHY

Claudia Preininger is a senior researcher at Austrian Institute of Technology GmbH. Her research is focused on formulation development, biopolymer-based (plastic free) coatings for slow-release fertilizers, and biobased biological formulations for biocontrol and plant growth promotion, including seed treatment, composite coatings, capsules, beads, granules, and foliar spray.

BEATRICE KULLI

Head of the Soil Ecology Research Group
Zurich University of Applied Sciences (ZHAW)

Greenhouse cultivation practises affect soil health indicators

ABSTRACT

Large-scale greenhouses in Switzerland account for a relatively small proportion of land cover, yet the number of hectares dedicated to greenhouse cultivation has steadily increased in recent years, particularly for greenhouses with solid foundations However, the construction phase poses a risk for soil compaction, and subsequent management practices, such as hors-sol production, may alter biological soil properties due to the covering of the bare soil by synthetic sheets and the lack of plant roots. This raises the question of whether greenhouse soils should be considered as part of the crop rotation areas.
In this study, soils of seven greenhouses with different cultivation practices (soil or hors-sol production; and alternation between soil cultivation in winter and hors-sol production in summer) were compared with soils outside the greenhouses. The study focused on the impact of greenhouse practices on biological (i.e., microbial biomass carbon, basal respiration and microbial diversity and community structure) and physical properties (i.e., bulk density, saturated hydraulic conductivity, volume of coarse pores and penetration resistance) of soils. Soil profiles were further examined in order to assess depth-dependent effects of the cultivation practices on soil characteristics.

The results indicate that the construction of greenhouses primarily affects soil physical properties, with compaction effects observed both inside and outside greenhouses, indicating that the impact of construction affects an area larger than the foot-print of the greenhouse itself. The status of soil compaction inside and around the greenhouse correlated well with the greenhouse building during wet conditions.

Soil biological parameters were mainly influenced by cultivation practices, with greenhouse soils used for hors-sol production exhibiting lower levels of organic matter and lower microbial activity compared to other cultivation practices. Microbial biomass carbon as well as basal respiration were strongly correlated with soil carbon content. Therefore, greenhouse soils with soil production showed higher microbial activity due to the increased amount of soil organic matter built up by the peat pellets brought in with the seedlings. The bacterial and fungal communities in greenhouse soils differed from those of conventional arable lands. Such changes were mainly reflected in the community composition (beta-diversity) rather than alpha-diversity (i.e., species richness or Shannon Index), suggesting that alpha diversity is not a suitable microbial indicator for soil disturbance. Furthermore, a core microbiome for greenhouse soils with indicative taxa for greenhouse soils was identified. Overall, our soil microbiome analyses revealed that greenhouse soils did not undergo a loss in microbial diversity, although their microbiomes significantly differ from those in arable lands.

The question of whether greenhouse soils meet the criteria for crop rotation areas cannot be conclusively answered based on the small sample size. Further investigations, particularly for greenhouses with hors-sol or alternation between hors-sol and soil-bound cultivation are needed. More in-depth studies on the soil microbiomes as sentinels for soil perturbation could help distinguish poorly managed from severely disturbed soils by exploiting the habitat-connectedness of the microbial community structure.

BIOGRAPHY

Beatrice Kulli holds a Doctorate in Natural Sciences from the ETH Zürich. She is Head of the Soil Ecology Research Group at the Zurich University of Applied Sciences.

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PASCAL BOIVIN

Group Leader, Soils and Substrates
Institut Terre-Nature-Environnement
HEPIA, HES-SO Genève

Monitoring carbon stocks in arable land: sources of errors, improvement of the one-layer equivalent soil mass method and minimum detectable change

ABSTRACT

Reliable determination of the soil organic carbon stock (SOCS) and its time trend at field scale is a key condition to value soil organic carbon (SOC) sequestration as a negative emission technology (NET) at farm level. Limiting the stock estimation to 30 cm depth is acceptable on the range of some decades (Balesdent et al., 2018). The carbon stock, however, is not directly estimated from the SOC content. SOC content must be multiplied by the bulk density (BD) of the corresponding layer. BD determination is time consuming and tedious to determine. Moreover, it changes with time due to soil swelling with water, soil tillage, and changes in SOC. Therefore, the changes in SOCS must be monitored on an equivalent soil mass (ESM) basis, by referring to the sampled soil mass of the previous sampling rather than to a constant depth layer. Corrections of the mass, simplification of the soil mass determination overcoming the BD determination issue, as well as a simplified one-layer method have been proposed (Wendt and Hauser, 2013). However, this simplified ESM method requires the sampling and analysis of at least two layers for sampled mass correction. Moreover, the field volume percentage of the coarse (> 2 mm) fraction must be determined and removed from the sampled layer volume, which is not well documented. On the other hand, and to our best knowledge, private companies providing SOCS certificates sample the soils at constant depth using mechanical gauges that do not allow to control the quality of the extracted core. The errors associated with these different technical options need to be clarified.

This study was performed by sampling 60 fields from different farms of the Swiss Leman-Lake region. It aimed at providing a full reliable methodology to determine SOCS at field scale, while solving the remaining issues, namely to determine the errors associated to the different parameters estimated and to simplify the ESM one-layer method to decrease the sampling and analytical costs. The minimum detectable change was determine (i) for sampling performed using the mechanical gauges at constant depth, (ii) for the ESM one-layer method as described in (Wendt and Hauser, 2013), (iii) the additional error introduced by coarse fraction estimation and gauge diameter and (iv) a simplification of the one-layer ESM method taking into account local average properties of the soil below the 0-30 cm sampled layer.
We conclude that the classical constant depth automatic sampling cannot be used for carbon stocks monitoring, while the proposes simplified one-layer ESM method yield acceptable minimum detectable changes allowing to detect most changes in a 5 to 10 year time lag in Swiss arable land.

BIOGRAPHY

Pascal Boivin is professor of Soil Science, president of the European Confederation of Soil Science Societies. He is leading research in soil physics, on soil quality indicators, soil quality management, and regenerative agriculture. With his group, he is focusing on the impact of soil organic carbon and soil organic carbon forms on soil physical and biological quality, and on how farming practices influence soil quality and soil organic carbon content.

MINIMUM INDICATORS & METRICS: INPUT TALKS

SAM RÖTTJERS

Bionetwork Analyst
Biome Makers

From science to applications: Microbiome as a bioindicator for management practices

ABSTRACT

Agroecosystems are human-managed ecosystems subject to generalized ecological rules. Understanding the ecology behind the assembly and dynamics of soil fungal communities is a fruitful way to improve management practices and plant productivity. In particular, a mechanization with ecological computing to analyze the soil microbial networks. Thus, monitoring soil health would benefit from the use of metrics that arise from ecological explanations that can also guide agricultural management. Beyond traditional biodiversity descriptors, community-level properties have the potential of informing about particular ecological situations. Our observations using traditional approaches show results concurring with previous literature: the influence of geographic and climatic factors on sample distributions, or different operational taxonomic unit (OTU) compositions depending on agricultural managements. Furthermore, using network properties, we observe that fungal communities range from dense arrangements of associations to a sparser structure of associations, indicating differential levels of niche specialization. We detect fungal arrangements capable of thriving in wider or smaller ranges of temperature, revealing that niche specialization may be a critical soil process impacting soil health. Low-intervention practices (organic and biodynamic management) promoted densely clustered networks, describing an equilibrium state based on mixed collaborative communities. Thus, we hypothesize that network properties at the community level may help to understand how human intervention (land use) can affect community structure and ecological processes in agroecosystems impacting food quality production.

As an attempt to understand the underlying ecological processes explaining how microbial communities are shaped, most studies currently focus on correlative evidence between specific taxon abundance, diversity metrics, and environmental factors or community phenotypes. And although valuable, it has been argued that this strategy does not allow understanding the underlying ecological mechanisms by which communities react to environmental factors or by which these communities organize to perform an ecosystem-level process. Hence, developing a strategy to mechanistically understand the fungal component of the soil microbiome has general implications in monitoring soil health and may be of particular interest for guiding management strategies of agroecosystems. A metric system that verifies the sustainability on the farm based on soil health functions would allow growers to measure and improve the adoption of sustainability best practices. Ecological communities are often defined by functional traits, which result from the aggregation of taxon characteristics or through properties arising from specific combinations of taxa. Methodologically, there have been different strategies to measure such properties in microbiomes, but here we aimed at describing community-level properties by combining large-scale associational networks (i.e. metaweb) and a methodological innovation to split inferred associations into local communities. We argue that integrating the metaweb-inferred associations with the particular subset of taxa from local communities will allow the estimation of network properties to obtain information about the local microbial ecosystem serving as community-level properties. Our observations using traditional approaches show results concurring with previous literature: the influence of geographic and climatic factors on sample distributions, or different operational taxonomic unit (OTU) compositions depending on agricultural managements. Then, we used network properties (i.e modularity, clustering coefficient) based on large-scale associations (cooccurrences and co exclusions) as proxies of ecological strategies at the community level (e.g., niche differentiation, competition processes).

BIOGRAPHY

Sam Röttjers is a Bionetwork Analyst at Biome Makers, where his role involves translating scientific insights into tangible solutions through large-scale data analysis and software development. Under the mentorship of Karoline Faust, he pursued his doctoral studies on microbial networks and developed analytical tools to investigate their structure and relationship to microbial ecology. Today, he leverages his experience and interest in agriculture to contribute to the dynamic intersection of scientific exploration and practical implementation.

NATACHA BODENHAUSEN

Senior Scientist
Research Institute for Organic Agriculture FiBL

Predicting soil fungal communities from chemical and physical properties

ABSTRACT

The information on the microbiome present in agricultural soil can be useful for making soil management decision. While it is well established that the diversity of soil microbes is largely controlled by environmental variables, microbiome community prediction from soil properties is emergent. This study examined whether soil physico-chemical properties could be used to predict the composition of soil fungal communities through multivariate ordination. Soil samples were collected from 59 arable fields in Switzerland, and physico-chemical soil properties were paired with profiles of soil fungal communities. The composition of fungal communities was characterized using long-read sequencing of the entire ribosomal internal transcribed spacer. Redundancy analysis was used to combine the physical and chemical soil measurements with the fungal community data. We identified a set of 10 soil properties that explained the fungal community composition. Soil properties with the strongest impact on the fungal community included pH, potassium and sand. The model was evaluated using leave-one-out validation and proved to be successful for most soils, with only 4/59 soils having poor correlation coefficients between observed and predicted communities. Prediction was less successful for soils with unique properties or diverging fungal communities, while it was most successful for soils with similar characteristics. Reliable prediction of microbial communities from chemical soil properties could eliminate the need for complex and laborious sequencing-based generation of microbiota data. This could make soil microbiome information available for agricultural purposes such as pathogen monitoring, field inoculation or yield projections.

BIOGRAPHY

I have been working as a senior scientist in the department of soil sciences at the research institute for organic agriculture FiBL for the last six years. Before, I was a postdoc with Marcel van der Heijden at Agroscope. My research focuses on the effect of management systems on the soil microbiome, breeding for resistance to drought, and improving inoculation with arbuscular mycorrhiza fungi.

MINIMUM INDICATORS & METRICS: INPUT TALKS

TOBIAS HEINRICH

Research Assistant
OTH Regensburg

Automatic soil biology analysis by computer vision

ABSTRACT

Biodiversity is a primary basis of life of the human being. It is fundamental for supply of food and water, regulating air and water quality. To monitor and affect the biological development process, the fungi to bacteria ratio is an important indicator for succession level of an ecosystem. The ability to determine this ratio without complex chemical applications is part of the project Electronical Laboratory for Intelligent Soil Examination (ELISE). The sample preparation for shadowing microscopy, to examinate biological soil properties, is time consuming manual work. The outcome depends on subjective skills of the operator, furthermore the results are mostly not quantitative. The database on biological soil properties is not sufficient for an integrated modelling on a multidisciplinary scale.

This project combines two progressive approaches to develop a tool that is easy to use and gives in situ results that can be used for many purposes: Automated high-throughput microscopy for soil samples, and Image recognition of soil microbes. Several mechanical and optical tests on soil samples are covered within this project. To analyze the fungal to bacteria ratio, modern process engineering methods are used to prepare a microscope sample by creating a suspension, applying the sample to a microscope slide and add a cover slip. This is realized in a defined and reproductive procedure. The samples are observed by a camera, which is attached to a transmitted light microscope. The automatic analysis, done with computer vision algorithms, aims to quantify bacterial and fungal biomass in the actual sample view. Moreover, the algorithm can classify organisms according to their color and shape.

To get a processable picture, several images from different focal levels must be taken through the sample thickness. Parts of each image, are in focus at the actual layer, are merged to a whole depth of field picture, by focus stacking. This produced picture is used to classify, locate and quantify – in first step filamentous organisms e.g., fungal by image sematic segmentation. The result represents an image sized mask, which indicates the class of fungi with class equivalate values at the pixel positions – covered by the organism. This information is used to calculate the fungal mass per gram soil. To quantify the bacterial biomass two approaches are implemented. For low density of bacterial existence, the individual bacteria is counted for a part of the field of view by an image detection algorithm to be extrapolate afterwards to the mass per gram soil. For high density of bacterial occurrence, specified regions of interest with only bacteria present are chosen. An image classification which has been pretrained by pictures of bacterial density patterns – previously determent by making the sample countable due to preforming sample dilutions, is done. The second option for high density bacterial count is, to automatically preform dilutions until the image detection is confidently countable. Having a tool, giving both – self-explanatory images and data – allows to discuss soil biology situation with several instances e.g., farmers, citizens, scientist, political stakeholders, to get the biodiversity back to a level where all ecosystem functions work satisfactorily.

BIOGRAPHY

I'm a research assistant at the OTH in Regensburg and work on a project called ELISE (Electron-ical Lab for Intelligent Soil Examination). This project aims to prepare and perform soil samples by microscope automatically. The produced images are observed by image recognition to quantify and extrapolate bacteria and fungi that are present in the sample.

KONRAD METZGER

Post-Doctoral Researcher
Field-crop Systems and Plant Nutrition
Agroscope

Measuring soil quality indicators using visible and near-infrared spectroscopy

ABSTRACT

For an efficient management of agricultural soils, we need a fast and affordable way of measuring soil parameters or properties associated to soil health. In the last decades, visible and near infrared (vis-NIR) spectroscopy has been a subject of interest as a technique to predict a set of soil parameters based on the interaction of the NIR radiation (350-2500 nm) with soil constituents such as clay, organic compounds and iron oxides. With the help of chemometric models, the information contained in the spectra is related to the laboratory data and once the model is set up, it is then possible to predict soil parameters while significantly reducing the number of soil samples that must be analysed according to traditional wet chemical protocols. Strong calibration models and soil spectral libraries are already set up for a range of key soil parameters such as soil organic carbon (SOC), texture (clay, silt, sand), and total nitrogen (N) for soils around the globe. Vis-NIR soil spectroscopy is on the way of becoming a viable extension to wet chemical laboratory analyses, but there is also still more research to be done. One big question is, for example, how to facilitate vis-NIR readings directly in the field, considering that, until now, the majority of the research has been done on dried and sieved soils in order to get rid of the deteriorating effect of soil moisture and aggregates on Vis-NIR spectra.

To contribute to this field of research, we conducted an experiment aimig at formulating the best practice for recording vis-NIR spectra directly in the field (in-situ). For this goal, we scanned soils from nine different long-term experiments in Switzerland with two types of spectrometers, i.e., a consumer grade spectrometer with low range and resolution (1350-2500 nm, 16 nm resolution) and research grade spectrometer with high range and resolution (350-2500 nm, 2.8-8 nm resolution). We were able to successfully calibrate partial least squares regression models for clay, soil organic carbon, total N, cation exchange capacity and pH ($R^2 > 0.6$, RPIQ > 1.9). In addition, we were also able to evaluate the best scanning position among different positions of the sensor on: untreated soil surface, cleaned surface, slightly compressed surface and along the sides of a 20-cm-long core. The recommended best practice is to take a soil sample with a corer and scan along the sides of the 20-cm long core in replicates (five replicates for the research grade spectrometer and ten replicates for the consumer grade spectrometer). In another research, we looked into the application of vis-NIR spectroscopy for the prediction of soil mineral N (NO3 + NH4), easily oxidizable carbon (permanganate oxidizable carbon, POXC) and the SOC:clay ratio. The mineral N is a crucial parameter to manage N fertilization of crops and can be used to maximize crop yield with minimum negative environmental impact from N pollution. Mineral N could not be predicted with our vis-NIR models to a satisfactory level of accuracy ($R^2 < 0.5$, RPIQ < 2.1). The POXC describes the amount of easily available carbon for soil microbiota and it is considered more reactive to changes in management practices than SOC. Based on our models, we could successfully predict POXC ($R^2 > 0.6$, RPIQ >2.5) from in-situ soil spectra. The SOC:clay ratio can be used as an indicator for soil structural quality (Johannes et al., 2017). We found that models which were calibrated for directly predicting the SOC:clay ratio performed better (R^2 0.75, RPIQ 2.55) than calculating the SOC:clay ratio from separately predicted SOC and clay values (R^2 0.59, RPIQ 1.54).
Our results confirm that vis-NIR soil spectroscopy has the potential to predict a set of soil parameters that can be used as indicators of soil health. Because the spectra are a snapshot of everything present in the soil that interacts with the vis-NIR radiation, there may be the potential to derive other indicators of soil health once the limits of this promising technique will be fully clarified.

BIOGRAPHY

My work focuses on the use of visible and near infrared spectroscopy to predict soil parameters related to soil quality and soil fertility. My main project is part of the agroscope research project INDICATE, where we develop indicators to measure farm environmental impacts, more specifically in the proximal sensing project, which focuses on the use of vis-NIR spectroscopy for soil indicators. Additionally, I also participate in the H2020 EJP SOIL project ProbeField where the application of vis-NIR spectroscopy in-situ is examined.

PETER LEHMANN

Senior Scientist and Researcher
ETH Zürich

Characteristic times of soil water partitioning as soil health indicators

ABSTRACT

Physical indicators of soil health must be relevant for the ecological processes in soils, integrate various soil hydraulic properties, and should be quantifiable at various scales. We propose characteristic times for the following processes as new indicators of soil health: ponding time limiting water infiltration, attainment of field capacity, and evaporative phase transition. These characteristic times can be measured in the field, predicted from soil hydraulic properties, and have the potential to be deduced from satellite data at national and global scale. These times are also sensitive to structure formation and structural properties that are important for chemical and biological soil health (soil organic content).

1. Characteristic times for water partitioning: Rainfall water is partitioned into surface runoff and infiltrating water that is subsequently redistributed to gravity drainage and evapotranspiration. These three processes (generation of surface runoff, gravity drainage, and evaporation) are related to characteristic time scales depending on soil hydraulic properties (see Figure 1). The water infiltration during heavy and long-lasting rainfall can be limited by soil hydraulic properties (water retention and water flow velocity as function of soil water content) and will result in surface runoff. The generation of runoff increases soil erosion and is thus a strong indication for unhealthy soils. The presence of soil structures increases the infiltration rate also in fine textured soils and suppresses the generation of surface runoff. After wetting by infiltration, the water content can be high and close to saturation, resulting in anaerobic conditions that will have negative effects on ecosystem functions. An efficient drainage by gravity to re-fill large pores with air is thus an indication for a healthy soil. The gravity drainage is related to the attainment of field capacity, that can be defined by a hydration state when drainage fluxes become smaller than evapotranspiration rate. The value of field capacity is mainly related to the unsaturated hydraulic conductivity of the soil matrix, but the time for its attainment is affected by the presence of structural pores with larger hydraulic conductivity.
For wet conditions, water is extracted by roots and evaporation with a rate controlled by atmospheric conditions (potential evaporation rate). For a topsoil with large aggregates or a mulching layer, vapor is not emitted directly from the surface but from an evaporation plane below such overlying layer with low capillary forces. The formation of an evaporation plane below the surface reduces the water loss and extends the period with favorable environmental conditions in the subsurface. When the water transport to the evaporation plane becomes limited, the evaporation plane recedes to larger soil depths, with a decaying evaporation rate controlled by vapor diffusion. The change from rather constant to decaying evaporation rate depends on soil hydraulic properties; healthy soils with a wide range of pore sizes have a large transition time from constant rate to the onset of diffusion-limited evaporation rate. In summary, healthy soils have large values for time of ponding and evaporation stage transition, but a short value for attainment of field capacity.

2. Measurements and predictions based on structural properties: The quantification of the characteristic time can be measured directly in field experiments and with soil moisture networks. At larger scale, the time could be deduced from satellite-based water content data. For all times described in previous subsection, analytical expressions exist that predict the values as function of the parameters of the soil hydraulic properties. However, these predictions neglect the role of soil structures that can be quantified using advanced imaging techniques or visual assessment in the field. To predict the effect of structures on the characteristic time, structural properties should be linked to environmental covariates.

Acknowledgement: This research is part of the project Artificial Intelligence for Soil Health, funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or of the Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

Funded by
the European Union

BIOGRAPHY

Peter Lehman is a Senior scientist and Lecturer at ETH Zurich. His research focuses on soil physics from pore to global scale.

FRANZISKA HÄFNER

Scientist, Soil Quality and Soil Use
Agroscope

Soil quality and management evaluation of Swiss agricultural soils – the Bodencockpit project

ABSTRACT

The evaluation of agricultural soil quality to sustain soil multi-functionality has been a key focus of the last years and is still ongoing. Numerous soil indicators and assessment systems for soil quality and soil monitoring are available, tackling different stakeholders, research questions and goals, e.g., focusing on soil monitoring, the evaluation of changes in land system, or farm management impacts. The objective of the Bodencockpit project is to provide an easy-to-use methodology and set of practical and sensitive soil quality indicators to evaluate soil quality and management at the plot level for arable and mixed farms in Switzerland. The indicator selection was based on currently available threshold values or response curves from literature. Three sets of information were used for soil quality assessment: (i) pedo-climatic conditions at the site, (ii) measured soil attributes (iii) management activities. Considering pedo-climatic conditions, such as water balance, soil type, texture, rootable depth and slope, the functional potential and limitations can be estimated for a site For the manageable soil attributes used as measured state indicators we included physical (bulk density, gravimetric air content at -100 hPa, coreVESS, penetration resistance), chemical (Corg/clay ratio, permanganate oxidizable C, total N and P, available nutrients (P, K, Mg), pH, base saturation), and biological indicators (earthworm number and biomass, soil respiration, microbial biomass and enzyme activity).. The measured soil indicators then provide a quantification of the actual soil state. Linking soil potential and state, as proposed by Vogel et al. (2018) uncovers the potential of improvement for a specific soil function. Moreover, drawing the connection to management indicators (for example tillage intensity, organic amendments, compaction and erosion risk, humus balance, crop diversity, etc.) can even determine the source of specific problems or serve as decision support tool for the farmer, pointing towards improvement options. For calibration of our approach, we collected soil samples from four Swiss long-term field experiments, including only practical treatments and no unfertilized control. First results related to physical soil indicators will be presented in relation to management indicators. We will quantify several key soil functions, including the water storage capacity and infiltration function and the soil structural stability, partially following recommendations by Vogel et al. (2019) and Greiner et al. (2018).

BIOGRAPHY

I am an agricultural scientist, working on the Bodencockpit project in the Soil Quality and Soil Use Group at Agroscope, Reckenholz. Within the project, I am focusing on the evaluation of soil quality with the intent of identifying a suitable set of indicators and linking them to soil management to provide better decision support in practice. With my background in plant nutrition and environmental sciences, I am also interested in relating fertilizer and SOM management indicators to N and P use efficiency, in order to decrease nutrient surpluses into the environment. My research aims to enhance agricultural production systems‘ sustainability and resilience and support closing nutrient cycles.

HOLGER STALZ

Leader
European Biopharma Technical Solution Team
Agilent

Determination of Per- and Polyfluoroalkyl Substances in Soils Using Agilent Carbon S SPE by LC/MS/MS

ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) have been used in industry and consumer products since the 1940s and have been widely detected in drinking water, wastewater, ground and surface water, soil, and other complex matrices. This contamination of the environment with PFAS is a serious concern worldwide, due to their ubiquitous presence, persistence, and toxicity. Their chain of strong fluorine-carbon bonds makes these chemicals persistent and bio-accumulative – linking them to health hazards in humans and wildlife. Key challenges in the analysis of per and poly-fluoroalkyl substances (PFAS) are the potential of adsorption of target compounds or the introduction of interferences during sample handling. These problems may occur at any point in the sample workflow from the initial collection of field samples to sample preparation and analysis. As a result, it is common practice to avoid certain materials during sample handling and analysis.

Here, we will show a clean up method for soil by Carbon S cartridges and the detection of PFAS by LC/MS/MS methods. The method incorporates a basic methanol extraction followed by a passthrough matrix removal step using an Agilent Bond Elut Carbon S solid phase extraction (SPE) cartridge and quantitative analysis by LC/MS/MS. For the 59 PFAS tested, the average recovery at the low spiking concentration (0.625 ng/g) was 99.9% with a relative standard deviation of 13.5%. Depending upon the soil matrix, the use of the Bond Elut Carbon S cartridges can improve chromatographic peak shape and retention for early eluting compounds such as PFBA.

BIOGRAPHY

Holger Stalz received his PhD degree in the field of Physiological Chemistry at the University Cologne and lead the Mass Spectrometry lab at the Institute of Biopolymer Chemistry at the TU Munich Weihenstephan during his Post Doc. Following a position as an LC/MS Field Application Specialist for a leading instrument provider, he joined Agilent Technologies as a Product Specialist in 2011 and consults customer in Switzerland and Austria during their buying process for their applications. Since February 2023, he leads the European BioPharma Technical Solution Team at Agilent and supports user of LC/MS systems to develop new strategies in Nitrosamine analysis, Oligonucleotide characterization and challenging Food and Environmental applications such as PFAS analysis in water and soils.

FABIO VOLKMANN

Engagement Manager
Climate Farmers

BENCHMARKS – Building a European Network for the Characterisation and Harmonisation of Monitoring Approaches for Research and Knowledge on Soils

ABSTRACT

In Europe, a joint assessment undertaken by the Soil Health and Food (SH&F) mission board and the Joint Research Centre (JRC) declared that 60-70% of soils in Europe are currently considered unhealthy due to e.g. pollution, excess nutrients compaction and soil degradation (A Soil Deal for Europe). As such, the SH&F mission set the goal to have 75% of European soil healthy or significantly improved by 2050. This is in line with other important European initiatives such as the Green Deal and EU Farm-to-Fork Strategy, as well as with preparations for a new EU law on the protection of Soil Health that aims to protect soils on the same legal basis as air and water. Meanwhile, the private sector too, is proposing solutions for sustainable food and biomass systems, where soil health is considered an integral part of future sustainability.

Soil health is defined as the capacity of a soil to support multiple ecosystem functions, such as primary productivity, nutrient cycling, carbon regulation, water quality and regulation and providing a habitat for biodiversity. Monitoring soil health has been on the research agenda for many years, with many proposed sets on indicators for the evaluation of soil health. However, these approaches are often top down and do not provide the information needed by land managers to help them identify the issues and define practices which can improve the health of soils.

BENCHMARKS, a Horizon Europe funded project, aims to develop a transparent, harmonised, and cost-effective framework for measuring soil health across Europe. The project will co-develop the framework within 24 European landscape case studies, with a focus on multi-scale and multi-user monitoring. Working with a range of stakeholders such as land managers, legislators, value chain businesses, NGOs and policy makers, BENCHMARKS will define a monitoring system that is pertinent to the objective of assessment, applicable to the land use, and logistically feasible. Key outcomes of the project will include a harmonized and cost-effective framework for measuring soil health, a review of proposed indicators from the EU Soil Mission and BENCHMARKS, an integrated soil health tool, and scientific underpinning of soil health incentivization schemes for value-chain businesses. This presentation will focus on the process of stakeholder engagement in the design and implementation of soil monitoring.

BIOGRAPHY

My role as stakeholder engagement manager is to develop a multi-stakeholder process (MSP) for BENCHMARKS to ensure that we collaborate and partner with stakeholders from the early stage of the project while being guided by diversity, inclusion, equity (DEI), and bottom-up approaches.

AMANDA MATSON

Senior Scientist, Soil, Water and Land Use
Wageningen University

Setting targets and thresholds for soil health indicators

ABSTRACT

Across Europe, it is estimated that over 60% of soils are currently unhealthy. The Soil Health and Food mission board has set the ambitious goal of having 75% of soil healthy or significantly improved by 2030. Yet while soil health has been defined qualitatively, there are still many gaps in our ability to quantitatively define a healthy soil. A myriad of soil indicators have been proposed that reflect soil health from various perspectives: sustaining plant and animal productivity, maintaining water and air quality, and long-term provision of other ecosystem services. Once appropriate indicators for different soils and land uses are identified, one next step is to assess measured indicator data using defined targets and/or thresholds in order to evaluate soil health.

There are four general approaches to setting indicator targets and thresholds for soil health assessment: fixed values based on research, fixed proportions of natural reference values, values based on the existing range (e.g. lower quartile of the observed distribution), and targets based on relative change (e.g. a 20% increase of the indicator's value). Each of these approaches has advantages and disadvantages, and there is no one method that is applicable for all regions and indicators. A key issue is our lack of knowledge around what a soil 'should' look like given a specific land use, and how to objectively define targets given those knowledge gaps. Here, we present a framework for combining all four methods into an easy-to-understand mechanism for setting targets and thresholds and assessing soil health.

Associated with this framework are key related questions that still need answers. At which scale can we set meaningful targets and thresholds for different land uses or crop type/soil type combinations? How do we link farm-level management with EU/national level monitoring? And most importantly: how to make this work in practice? We will present some thoughts on these issues and then invite the audience to share their views.

BIOGRAPHY

Amanda Matson is a senior scientist in the Soil, Water and Land Use team at Wageningen University and Research. With a background in soil biogeochemistry of agricultural and forest systems, she is currently focused on soil health. Her particular interests are the selection and use of soil indicators to support decision-making around sustainable soil use and management, as well as how innovative sensor and isotope techniques can provide insight into soils at different scales.

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Poster 3056: Synergism between production and soil health through crop diversification, organic amendments and crop protection

Poster 3058: Reference values for soil physical quality of mineral agricultural soils for environmental legislation and agricultural management

Poster 3069: Assessing Nitrogen Emissions from Irish Temperate Grass Silage: Insights from the DNDC Model

Poster 3075: Studying the Influence of Soil Biodiversity and Farming Innovations on the Mineral Nutrition and Stress Tolerance of Wheat Plants for Improved Resilience to Climate Change Impacts

Poster 3080: Influence of realistic pesticide application spray plan on the nitrogen cycle in bare soil systems

KEYNOTE:
AXEL DON

Deputy Director,
Thünen Institute of Climate-Smart Agriculture

Soil organic carbon management in agriculture – potentials and limitations

ABSTRACT

Carbon sequestration in soils has been discussed as important climate mitigation option with the potential to generate negative emissions. Agriculture requires such negative emissions since some of their greenhouse gas emissions are unavoidable and require compensation to achieve net zero. Expectation of soil's contribution to climate mitigation need to come down from theoretical numbers to realistic feasible estimates. Limiting factor for carbon sequestration in our soils is the available biomass. Moreover, in order to produce negative emissions with soil carbon, four criteria need to be fulfilled. Carbon sequestration need to be measurable, additional, permanent and without causing leakage effects. I will show examples to clarify the difference between climate mitigation, negative emissions and carbon sequestration and outline which measures are most powerful measures for a climate-smart agriculture.

BIOGRAPHY

Axel Don is a soil scientist and geo-ecologist working on questions related to soil carbon management in agriculture. Since 2017, he is the Deputy director of the Thünen Institute of Climate-Smart Agriculture, where he also led a research group from 2009-2016. He supervises 10 PhD and Master students and has published over 80 peer-reviewed papers, with an H-index of >40. Dr. Don completed his PhD at the Max-Planck Institute for Biogeochemistry and Eber-hard Karls University Tübingen, Physical Geography. This was preceded by a Diploma in Geoecology (Environmental Sciences) from the University Bayreuth and studies in Environmental Science at University Limerick, Ireland. He participates in European and German soil societies and is Topical Editor of the Open Access Journal SOIL.

SURJA GUPTA

Post-Doctoral Researcher
University of Basel

Modified soil erodibility global map using saturated hydraulic conductivity

ABSTRACT

Soil erosion is an important environmental process that leads to soil degradation and thus affects soil fertility, water retention capacity, and crop yield. The empirical RUSLE model is one of the most used models to predict the average annual soil loss for large spatial scales. Soil erodibility (K) is the only factor in the RUSLE model that integrates the inherent susceptibility of soil representing the structural stability of soil aggregates based on organic matter content and soil texture. However, K ignores the non-negligible direct effect of infiltration and drainage of surface runoff for soil erosion estimations, which has often been criticised by researchers using process-based models. Therefore, this study aimed to improve the representation of soil hydraulic properties in the K map. To do so, we collected the available saturated hydraulic conductivity (Ksat) literature data on a global scale with soil texture and organic carbon information and modified the permeability in the Wischmeier and Smith (1978) equation to consider Ksat. K factors with and without Ksat correction were further correlated with soil and remote sensing covariates using the Random Forest machine learning algorithm to create two K maps (soil texture-K map and Ksat-K map). K maps were eventually further used to calculate the annual soil loss with RUSLE. We validated our annual soil loss maps using continental or national sediment yield (SY) datasets. This study demonstrates the importance of accurately representing the hydraulic properties in soil loss estimation and discusses possibilities of validating soil erosion modelling on large scales.

BIOGRAPHY

I am a Post Doc in Christine Allwell's group at the University of Basel. I am an agricultural engineer by training and did my master's in Remote Sensing (RS) and GIS specializing in agriculture and soils. I did my Ph.D. in environmental science at ETH Zurich. My work is focused on the global mapping of soil hydraulic properties, linking hydraulic properties with soil erosion estimation, and application of Remote Sensing (RS), and GIS on agriculture and hydrology.

ANATOL HELFENSTEIN

PhD Candidate
Soil Geography and Landscape
Wageningen University

3D+T mapping in the Netherlands reveals soil organic matter changes between 1953 and 2022 at 25m resolution

ABSTRACT

Soil organic matter (SOM) is linked to six of the eight mission objectives of the Soil Deal for Europe and the 2023 Soil Health Law, which aim to restore the capacity of soils to support ecosystem services. In addition, carbon sequestration in SOM offers an opportunity for climate change mitigation. Coordinated efforts are underway to develop best practices for measuring, reporting, and verifying SOM changes, while simultaneously adapting agricultural systems to facilitate Carbon Farming as a means of mitigating greenhouse gas emissions. However, SOM continues to decrease in European croplands and peatlands. It is therefore no surprise that the increase of SOM and conservation of peat soils remains a global priority. With its intensive agriculture, degraded peatlands, and anthropogenic landscapes, the Netherlands is an ideal area for examining SOM changes to address today's challenges to soil health. Maintaining and increasing SOM requires high resolution, spatio-temporally explicit assessment to facilitate management and land use decisions tailored to local soil conditions. Therefore, we developed a modelling platform in 3D space and time (3D+T) as a new paradigm for SOM monitoring and mapping. It provides annual predictions of SOM and its uncertainty in the Netherlands, at 25m resolution between 0-2m depth from 1953-2022. We used machine-learning, 869094 SOM observations from 339231 point locations and spatially explicit environmental variables, or covariates. The covariates, which serve as proxies for soil-forming factors, are categorized into three types: static, dynamic in 2D space, and dynamic in 3D space. While climate, relief, and parent material were considered static, land use and the occurrence of peat were considered dynamic due to their greater propensity to anthropogenic influence over 70 years compared to the other soil-forming factors. To our knowledge, our approach is the first to use a 3D+T dynamic covariate and these are the first SOM maps in 3D+T on a national scale. In this work, SOM and absolute changes in SOM between two years are expressed as percentages.

Between 1953 and 2022, our findings indicate that there was a decrease of >1% in SOM on 14% of the land surface area of the Netherlands, which is equivalent to 4746km2. Furthermore, there was a decrease of >10% in SOM on 4.5% of the land surface area, which amounts to 1518km2, predominantly occurring in peatlands. In former peat layers now classified as mineral soil layers, average SOM declines ranged between 9-21% between 0-30cm depth. In bogs and brook-valleys, peat layers were often thinner than 1m. Here, SOM decreased by >25% between 1953 and 2022. Time-lapse maps spanning the entire 70-year period provide a visualization of these gradual changes over time at different depth layers. Although our findings indicate limited SOM changes in thick peat layers because we did not model below 2m depth, note that other studies still found a decline in carbon stocks and net CO_2 emissions in these areas. On reclaimed land, model predictions revealed that SOM changes were closely associated with land subsidence, compaction and peat layers below 80cm depth. In areas with thick peat layers on reclaimed land, we predicted SOM increases of >10% between 80-200cm depth. In areas with thin peat layers on reclaimed land, we found similar SOM increases between 80-150cm depth, below which SOM decreased by 10-25%. If peat layers closer to the surface rise above groundwater levels, carbon emissions will increase in the next decades. In the top 30cm of mineral soils, an average decrease of 0.1% was predicted in croplands and 0.1-0.3% when grasslands or forests were converted into croplands. The novel use of a 3D and 3D+T covariate has the advantage that we let machine learning detect complex relationships between SOM and peat occurrence . As a result, we found major changes in SOM not only in space but also over depth and time, especially in peatlands and reclaimed land. Therefore, we recommend that 3D+T modelling be incorporated in SOM reporting alongside point monitoring to provide spatially explicit information. The implications of this research extend beyond the examined spatio-temporal domain. By studying the relationship between covariates and temporal SOM changes using the 3D+T mapping methodology, we can identify the key drivers of these changes and predict future SOM changes. Peatland conversion, land reclamation, and agricultural intensification are ongoing worldwide, but many of the affected regions lack spatio-temporal soil and land use data. In light of the pressing challenges related to soil health, including preventing further loss of SOM in peatlands and increasing SOM in agricultural lands, the insights gained from these 3D+T maps are of global importance.

BIOGRAPHY

Anatol is a PhD candidate in the Soil Geography and Landscape group at Wageningen University, where he works under the supervision of Dr. Titia Mulder, Prof. dr. Gerard Heuvelink and Dr. Mirjam Hack-ten Broeke. He is currently working on a project to develop a high resolution 4D soil modelling and mapping platform for the Netherlands, or „Bodemkundig Informatie Systeem 4D“ (BIS-4D). Anatol is a soil scientist who completed a BSc in Geosciences from the University of Basel and a MSc in Environmental Sciences from the Swiss Federal Institute of Technology ETH Zürich with a Major in Biogeochemistry and Pollutant Dynamics. His main interest lies in using proxy and sensing methods, large datasets and statistical models to map soils over space and time to make sustainable land use decisions.

SANDRA SPIELVOGEL

Full Professor for Soil Science
Institute of Soil Science and Plant Nutrition
Christian-Albrechts-Universität zu Kiel

Deep-rooting cover crop mixtures: Highways to subsoil water and nutrient resources

ABSTRACT

The most important advantage of cover crop mixtures may arise from root biomass production, where some species respond with higher root/shoot ratios to species competition but also with synergism between species and root growth. These factors can contribute to subsoil C enrichment and contribute to the nutrition of cash crops after cover cropping.
We conducted a 13C pulse labelling experiment of six deep- and shallow-rooting cover crop species (Trifolium pratense, Trifolium repens, Festuca arundinacea, Lolium perenne, Raphanus sativus var. oleiformis, Brassica napus) in the field. The cover crops were grown in monocultures and three mixtures (legume/grass, legume/brassica and brassica/grass). We traced the C transfer from the cover crops into their root channels and calculated how much 13C was recovered during maize cultivation. Additionally, we quantified the relative nutrient and water uptake of maize from three different depth layers (0-30 cm, 30-60 cm, and 60-90 cm), using pipe-in-tube injection of nutrient tracers (15N-NH4+/15N-NO3-, Sr, Rb and Cs) and deuterated water to the respective depths. The cover crops were grown in monocultures and three mixtures on a Luvisol field site in Northern Germany.

Only the legume/grass mixture showed a 13C enrichment in the root channels in the subsoil at maize growth stage BBCH33, indicating that only this cover crop mixture was able to transport a higher proportion of the newly assimilated carbon to the subsoil, and/or that the mean residence time of the carbon that was transported to the subsoil layer in the clover/grass mixture was longer than that of the other variants. The total N-uptake by maize was 14–33% of the applied tracer, with the highest amount after the brassica/grass mixture, confirming that the decomposing root residues of cover crops do contribute to maize N-supply. In terms of nutrient uptake from the subsoil, maize grown after the legume/grass mixture (22% for N, 43% for K and 45% for Ca) and maize grown after the brassica/grass mixture (31% for N, 45% for K and 44% for Ca) achieved the highest uptake percentages from 30–90 cm depth in relation to the total tracer uptake.

Moreover, the maize following the brassica/grass cover crop mixture achieved an up to three times higher water uptake from 60–90 cm soil depth compared to any other cover crop variant at BBCH50. This suggests that especially late in the cropping season, when maximal water demand is expected, this mixture enables preferential access to deep subsoil water resources. We conclude that the more efficient soil exploration by the roots of cover crop mixtures containing grasses promotes the nutrient uptake of maize from the subsoil. This is surprising, considering the thin roots of Poaceae. Direct re-use of these fine root channels is unlikely for maize crown roots. Hence, we conclude that the observed better subsoil nutrient access after cover crop mixtures containing Poaceae is either an effect of root channel re-use by primary and seminal maize roots, or an indirect effect arising from Poaceae root exudates and degradation intermediates diffusing into the soil and increasing subsoil nutrient availability.

BIOGRAPHY

Sandra Spielvogel is a Full Professor for Soil Science (W3), Institute of Soil Science and Plant Nutrition, Christian-Albrechts-University, Kiel, since September 2017.
Her research is focused on soil organic matter and nutrient (N, P) cycling, degradation and stabilization, including the linkage between soil structure and soil processes. She is also interested in Microbial SOC and nutrient (N, P) transformations, plant-microorganisms-soil interactions in the rhizo- and detritus sphere, and spatial heterogeneity and variability of soil systems from the molecular to the landscape scale.

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SERENELLA SALA

Head of the Land Resource and Supply Chain Assessments Unit, Directorate for Sustainable Resources of the European Commission's Joint Research Centre

How the EU Soil Observatory is providing solid science for healthy soils

ABSTRACT

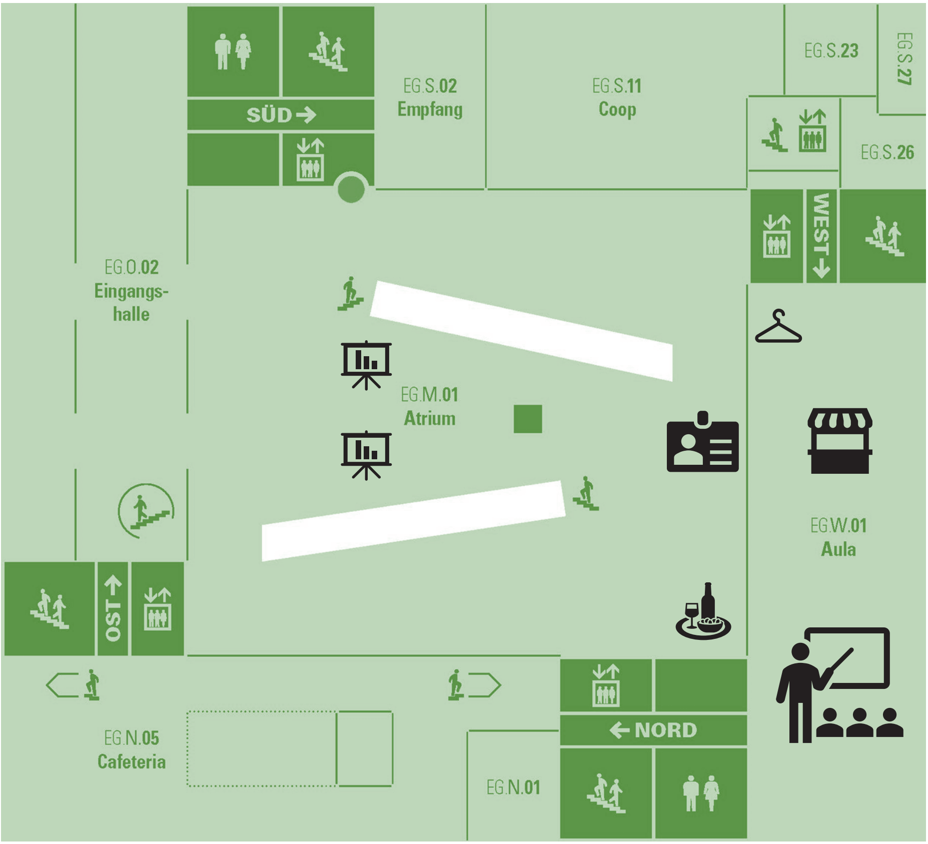
Soils are in the limelight: current political, economic and climate crises have prompted an unprecedented awareness about the importance of soil health for food security, climate and the biodiversity. This is reflected in the aspirations and numerous policy targets of the European Green Deal. Analysis shows that many soils across Europe are not in a healthy state. This is due to a range of degradational processes that include erosion, pollution, poor waste management and intensive cultivation practices as well as the loss of soil by urban and infrastructure expansion.

A novel soil health dashboard has been developed recently by the JRC's EU Soil Observatory. Through a convergence of evidence approach, the dashboard uses the current scientific evidence to highlight the location and extent of unhealthy soils in the EU, as well as the degradation processes behind them. In fact, the dashboard confirms that at least 61% of the EU's territory is experiencing unhealthy soils. It is worth remembering that our knowledge base for several processes, specifically diffuse pollution and compaction, is poor. This situation reflects the lack of investment and political drive to collect soil data. It is in this context that, through activities such as the LUCAS Soil Module and targeted research and innovation funded under Horizon Europe's Soil Deal for Europe Mission, several of these data gaps will be addressed. A key element in the implementation of the Soil Health Law will be progress in the establishment of an integrated soil monitoring system that captures changes in physical, chemical and biological characteristics and assess progress towards the vision of the EU Soil Strategy 2030. These need to be assessed through a range of data flows that supplement traditional field survey to provide novel perspectives. Key to these are various COPERNICUS systems to capture the increased uptake of sustainable soil management practices, the application of big data techniques and artificial intelligence to precision farming systems, citizen science programmes and greater sharing of management practices (e.g. through IACS).

BIOGRAPHY

Alessandra is the Director of the Directorate for Sustainable Resources of the European Commission's Joint Research Centre (JRC). As the science and knowledge service of the European Commission, the JRC's mission is to support EU policies with independent evidence throughout the whole policy cycle, to positively impact society. Alessandra joined the European Commission after graduating in Economics from the University of Genoa. She formulated transport policies in the former Directorate-General for energy and transport and then in the Cabinet of Vice President De Palacio, working closely with the European Maritime Safety Agency and the European Aviation Safety Agency. In 2009, Alessandra joined the JRC as Head of the Maritime Affairs Unit. She was subsequently appointed Head of the Demography, Migration and Governance Unit where she was responsible for the Knowledge Centre on Migration and Demography (KCMD).

FLOORPLAN



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