PROGRAMME and BOOK OF ABSTRACTS

International Union of Soil Sciences

2nd Workshop on

Soil degradation control, remediation and reclamation

Sofia, Bulgaria,
9th – 11th June, 2025

Commission 3.5
International Union
of Soil Sciences

Nikola Poushkarov Institute of Soil Science, Agrotechnologies and Plant protection, (ISSAPPNP) Agricultural Academy

in cooperation with the
Potsdam and Wroclaw Universities

Universität Potsdam

Federation of the Scientific and Technical Unions, Sofia ,108 Rakovski Str.

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PROGRAMME

9th JUNE 2025 – PLENARY SESSION

11:30 – 12:30 – Registration

13:00 – 13:15 – WELCOME ADDRESS, Irena Atanassova

13:15 – 13:35- WELCOME ADDRESS - Rainer Barits – online presentation

13:40 – 14:00 - ADVANCES IN SOIL RESEARCH TASKS AND REQUIREMENTS FOR A BETTER UNDERSTANDING OF A SUSTAINABLE ENVIRONMENT – Rainer Horn – online presentation

14:05 – 14:25 - ADVANCING SOIL DEGRADATION CONTROL, REMEDIATION AND RECLAMATION THROUGH THE ANAEE RESEARCH INFRASTRUCTURE - Biljana Dordevic

14:30 – 14:50 - LIVING LABS FOR SUSTAINABLE SOIL MANAGEMENT: A SYSTEMATIC REVIEW OF GLOBAL PRACTICES AND PERSPECTIVES, Eren Taskin, Natalia Rastorgueva, Lizzie Foley, Rita Noto, Luigimaria Borruso, Stefano Cesco, Tanja Mimmo

14:55 – 15:15 - SOIL DEGRADATION, REMEDIATION AND LAND MANAGEMENT IN THE SITES OF HISTORICAL ORE MINING AND PROCESSING – CASE STUDIES FROM THE SUDETES - Anna Karczewska, Agnieszka Dradrach, Katarzyna Szopka, Karolina Lewińska.

15:20 - 15:50 – Coffee break

15:50 - 16:10 - SOIL DEVELOPMENT AND SPONTANEOUS VEGETATION GROUTH ON MINE RESIDUE DEPOSIT AT DIFFERENT CLIMATES IN NAMIBIA AND SOUTH AFRICA - Stefan Norra, Florian Blum, Flavia Digiacomo, Elisabeth Eiche, Florian Eichinger, Kamuiua Kamundu, Lena-Sophie Kuhr, Karl-Gerhard Richter, Philipp Rinkel, Sanja Russ, Dawid Saayman, Rosa Sengel, Theo Wassenaar, Kai Witthüser

16:15 – 16:35 - AFRICAN DARK EARTHS ARE PATHWAYS TO ENHANCED SOIL CARBON, NUTRIENTS AND CROP PRODUCTIVITY IN GHANA AMIDST THE CHALLENGE OF HIGH MERCURY LEVELS - Caleb Ocansey, Vincent Logah, Edward Yeboah, Emmanuel Baidoo, Joshua Gyindayu Abisah, Thomas Adjei-Gyapong and Ben Banful

16:40 - 17:00 - REMATRIATING THE SOIL BY INTEGRATING INDIGENOUS KNOWLEDGE SYSTEMS WITH MODERN SOIL SCIENCE FOR SUSTAINABLE LAND CARE: CASE STUDIES FROM SOUTH AFRICA - Simeon A. Materechera

17:05-17:25 - SOIL AGGREGATE STABILITY AND ORGANIC CARBON STOCKS IN PANDAMANTENGA PLAINS, BOTSWANA: TOWARDS SUSTAINABLE LANDUSE - Peter N. Eze, Patience Ponyane, Ferdinand J. Dina Ebouel.

17:30-18:10 - MEETING OF COMMISSION 3.5 of IUSS

10th JUNE 2025 - PLENARY SESSION

9:15 – 9:30 – Registration

9:30 - 9:50 - EFFECT OF BIOCHAR APPLICATION ON HEAVY METAL SOLUBILITY AND SPECIATION IN SOILS AND SUBSTRATES AFFECTED BY METALLURGICAL ACTIVITY IN BULGARIA - Irena Atanassova, Lyuba Nenova, Maya Benkova, Tsetska Simeonova, Mariela Stoykova, Milena Harizanova, Milchena Atsenova, Emilia Elenova

9:55 - 10:15 - BIOCHAR APPLICATION INFLUENCES PAHs FRACTIONATION IN SOILS - Bożena Smreczak, Aleksandra Ukalska-Jaruga, Joanna Ciepiel

10:20 - 10:40 - ASSESSING THE DYNAMICS OF ORGANIC CARBON AND NUTRIENTS IN SOIL AGGREGATE SIZE FRACTIONS UNDER TILLAGE AND NO-TILLAGE PRACTICES IN OXISOL OF CAMEROON - Elisabeth Kuissang Ngomsu, Dieudonné Bitondo, Adriano Sofo, Stéphanie Grand, Meret Aeppli, Georges Martial Ndzana

10:45 - 11:15 - Coffee break

11:15 - 11:35 - IMPACT ON THE QUALITY AND SUSTAINABLE USE OF SOILS FROM THE IMPLEMENTATION OF LARGE-SCALE SYSTEMS FOR THE PRODUCTION AND STORAGE OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES - Martin Banov, Viktor Kolchakov

11:40 - 12:00 - SULPHUR CONTENT IN RIBWORT PLANTAIN, SOIL AND AIR IN THE ENVIRONMENT OF THE MOLVE GAS FIELD, CROATIA - Željka Zgorelec , Jasmina Rinkovec, Martina Šilović Hujić, Suzana Sopčić, Valentina Gluščić, Aleksandra Perčin, Marija Galić, Ferdo Bašić, Ivica Kisić

12:05 - 12:25 - MODIFIED SPENT COFFEE GROUNDS AND BIOCHAR REMEDIATION OF HEAVY METAL CONTAMINATED URBAN SOILS IN GLASGOW - Prudence Mhlophe, Jaime Toney, Adrian Bass, John Crawford

12:30-14:00- Lunch, restaurant HAPPY – 145A Rakovski Str.

14:00-14:20 - RESTORING SOIL HEALTH AND P DYNAMICS THROUGH LESS INTENSIVE LAND USES: GRASSLAND ESTABLISHMENT AND REWILDING - Agustín Merino, Valentín Valentin Lopes de Gerenyu, Pablo Souza, Verónica Piñeiro, Irina Kurganova

14:25 - 14:45 - EFFECTS OF AMENDMENTS ON THE RELEASE OF ANTIMONY AND LEAD FROM SPIKED SOILS UNDER DIFFERENT MOISTURE CONDITIONS - Karolina Lewińska, Szymon Świątek, Izabela Komorowicz, Kayode Olabode, Anna Karczewska, Muhammad Iqbal, Sara Gil Oncina

14:50 - 15:10 - VARIABILITY IN THE DISTRIBUTION OF MAJOR AND TRACE ELEMENTS AND POLYCYCLIC AROMATIC HYDROCARBONS IN THE SURFACE LAYERS OF FOREST SOILS - Sabina Dołęgowska, Agnieszka Sołtrys

15:15-16:00 - Coffee break and POSTER SESSION

16:00 - 16:20 - GENETIC SOIL CLASSIFICATION AS A BASELINE FOR THE ASSESSMENT OF SOIL DEGRADATION IN SERBIA UNDER CLIMATE CHANGE - Ljubomir Životić, Ana Vuković, Rastko Petrović

16:25 - 16:45 - COMPARATIVE ANALYSIS OF SOIL DEGRADATION AND SOIL STRUCTURE IN CROPLANDS AFFECTED BY EROSION AND SOIL DEHYDRATION TREATED WITH A BIOLOGICAL SOIL CRUST FORMING ALGAL CULTURE - P. Futó, B. Madarász, G. Bernát, M. Futó, G. Jakab, J. Kutasi

16:50 - 17:10 - DYNAMICS, MOBILITY AND SOURCES OF HEAVY METALS AFTER BIOCHAR ADDITION IN CONTAMINATED AGRICULTURAL SOILS AROUND A COPPER SMELTER - Lyuba Nenova, Irena Atanassova, Maya Benkova, Milena Harizanova and Tsetska Simeonova

17:15 - 17:35 - SEPARATION OF MICROPLASTICS FROM SOIL - A RECOVERY EXPERIMENT - Milena Kercheva, Lev Tribis, Maya Staneva, Hristo Valchovski, Gergana Kuncheva, Yonita Perfanova, Katerina Doneva, Tsvetina Paparkova, Pavlina Vasileva

11th JUNE 2025 – FIELD TRIP

8:45 – 9:00 – DEPARTURE TO ASSAREL-MEDET OPENCAST MINE ("ST. ALEXANDER NEVSKI" CATHEDRAL SQUARE).

LIST OF POSTERS

1. MICROBIAL BIOFORTIFICATION OF ORGANIC AMENDMENTS FOR MANAGING ORGANIC CONTAMINANTS IN AGRICULTURAL SOIL - Antonio Gelsomino, Giulio Scarpino, Rossana Sidari, Maria Teresa Rodinò, Stefano Mocali, Sara Del Duca, Elisabetta Loffredo.

2. FACTORS AFFECTING VARIABILITY OF SOIL QUALITY INDICATORS UNDER EROSION CONTROL AND TRADITIONAL TILLAGE - Gergana Kuncheva, Milena Kercheva, Galina Petkova, Jonita Perfanova, Tsvetina Paparkova, Viktor Kolchakov, Galin Ginchev, Lev Tribis, Katerina Doneva, Milena Mitova.

3. ASSESSMENT OF SOIL WATER BALANCE COMPONENTS UNDER EROSION CONTROL AGROTECHNOLOGIES VIA EXPERIMENTAL DATA AND SIMULATION MODELS - Milena Kercheva, Gergana Kuncheva, Viktor Kolchakov, Maria Ivanova, Milena Mitova, Tsvetina Paparkova, Martin Nenov, Iliana Ivanova, Evgeni Enchev.

4. MODIFIED SPENT COFFEE GROUNDS AND BIOCHAR REMEDIATION OF HEAVY METAL CONTAMINATED URBAN SOILS IN GLASGOW - Prudence Mhlophe, Jaime Toney, Adrian Bass, John Crawford.

5. ASSESSMENT OF CROP PRODUCTION POTENTIAL OF SOME ARABLE SOILS FROM BĂRĂGAN PLAIN - Cosmin-Andrei Burcea, Eduard Surugiu, Daniel-Ionut Fudulu, Carmen Alina Gherghina.

6. PHYTOTOXICITY OF SOIL PORE WATER IN SOILS STRONGLY CONTAMINATED WITH COPPER AND LEAD - Agnieszka Dradrach, Anna Karczewska, Katarzyna Szopka

7. MACRONUTRIENTS AND BUFFER CAPACITY OF TWO SOIL TYPES UNDER BEAN CULTIVATION - Ana Katsarova, Miladin Nazarkov, Tsvetina Paparkova, Tsvetelina Metodieva, Iliyana Ivanova, Ralitsa Gavrilova

8. DO CREOSOTE-IMPREGNATED POLES CREATE A REAL SOURCE OF PAHS IN SOILS ON HOP PLANTATION? - Bożena Smreczak, Aleksandra Ukalska-Jaruga, Joanna Ciepiel.

9. SELECTED INDICATORS OF SOIL HEALTH IN VARIOUSLY CONTAMINATED URBAN GARDEN SOILS - Katarzyna Szopka, Anna Karczewska, Dariusz Gruszka, Iwona Gruss.

10. ARSENIC BIOACCESSIBILITY IN SOILS OF ZŁOTY STOK ALLOTMENT GARDENS - Kayode Olabode, Karolina Lewińska, Izabela Komorowicz.

11. SOIL CHEMICAL INDICATORS OF POTENTIALLY TOXIC ELEMENT MOBILITY UNDER RIVERINE PRESSURE IN SENSITIVE AREAS - Mariana Hristova, Nikolay Dinev, Viktoria Kuncheva, Ana Katsarova.

12. SUSTAINABLE BIOFERTILIZERS FROM LIVESTOCK WASTE: OVERCOMING BARRIERS TO SOIL RECLAMATION IN DEGRADED ATLANTIC LANDSCAPES - Antonio Moreno-Robles, Verónica Piñeiro, Eladio Parga, Pablo Souza, Rocio Valenciano, Daniel Silva-Abilleira, Carlos Herrero, José M. de la Rosa, Agustín Merino

13. INFLUENCE OF LONG -TERM BIOCHAR APPLICATION ON CO_2 AND NO_2 EMISSIONS ON FLUVISOL - Maya Benkova, Maria Ivanova and Irena Atanassova.

14. CO-PYROLYSIS OF MUNICIPAL SEWAGE SLUDGE AND OAK BARK: BIOCHAR CHARACTERIZATION, HEAVY METAL IMMOBILIZATION, AND ADSORPTION POTENTIAL, Michael A. Biney, Mariusz Z. Gusiatin

BOOK OF ABSTRACTS

CONTENT

ADVANCING SOIL DEGRADATION CONTROL, REMEDIATION AND RECLAMATION THROUGH THE ANAEE RESEARCH INFRASTRUCTURE

Biljana Đorđević
on behalf of the AnaEE Research Infrastructure[1]

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Abstract

Soil degradation remains one of the most pressing environmental challenges of our time, threatening biodiversity, food security, and the provision of essential ecosystem services. The AnaEE-ERIC (Analysis and Experimentation on Ecosystems - European Research Infrastructure Consortium) provides an integrated network for studying terrestrial and aquatic ecosystems under current and future environmental conditions. Among its broad scientific objectives, AnaEE also plays a pivotal role in enhancing the understanding and mitigation of soil degradation processes. Through a distributed network of research facilities across Europe, AnaEE provides access to a unique combination of controlled environmental facilities, *in situ* experimental sites, and advanced analytical and modelling tools. This integrated approach facilitates rigorous and standardized investigation into soil system responses to environmental stressors such as climate change, land-use intensification, and pollution. By combining long-term field monitoring, mesocosm-scale manipulation, and high-precision laboratory experimentation, AnaEE supports the assessment of soil degradation mechanisms and the evaluation of sustainable remediation and reclamation strategies across diverse ecosystems and climatic gradients. These facilities facilitate real-time monitoring of soil-plant-atmosphere interactions, greenhouse gas fluxes, hydrological dynamics, and biogeochemical cycles, allowing for the simulation of future climate scenarios and land management practices. In addition, cutting-edge molecular tools and analytical capabilities enable detailed characterization of soil microbial communities and functions, critical for soil restoration. Through interdisciplinary experimentation at ecosystem, landscape, and microcosm levels, AnaEE advances our understanding of how anthropogenic and environmental pressures affect soil function and resilience, and provides a robust empirical foundation for developing evidence-based strategies for sustainable land use and ecosystem restoration.

Keywords: AnaEE-ERIC, Analysis and Experimentation on Ecosystems, European Research Infrastructure Consortium, soil degradation

LIVING LABS FOR SUSTAINABLE SOIL MANAGEMENT: A SYSTEMATIC REVIEW OF GLOBAL PRACTICES AND PERSPECTIVES

Eren Taskin[*,1,3], Natalia Rastorgueva[2], Lizzie Foley[1], Rita Noto[1], Luigimaria Borruso[1,2], Stefano Cesco[1], Tanja Mimmo[1,2]

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Abstract

Soil functions as a living entity shaped by the activities of living beings in, on, and around it. Sustainable management of soil is crucial for terrestrial ecosystems, of which soil constitutes a vital component. However, globally, soils are currently facing great pressure due to their degradation and loss. Living Labs (LLs) can serve as dynamic hubs for collaborative innovation, particularly in real-world environments through the connections established between soil science, policy, and stakeholders to invert the course of soil degradation. This systematic review investigates the integration of LLs into soil research over the past decade. Our findings revealed that, among over three thousand works published on LLs in the last 10 years, only about 3% were inherently related to soil. Our findings indicated particular interest in Agricultural, Environmental and Policy aspects whereas studies focusing primarily on the Digital and Social aspects were limited. Geographically, LL-related soil studies are widespread, with significant contributions from Europe and North America, and emerging interest in regions like Sub-Saharan Africa and Oceania. Our review highlighted the crucial elements for successful implementation of LLs in soil health, including local priorities, practical feasibility, and inclusive stakeholder participation. Despite challenges such as resource limitations and stakeholder engagement, LLs have the potential to foster sustainable soil management practices globally if these initiatives are taken considering mentioned crucial aspects. Key recommendations include the establishment of thematic networks of LLs to enhance interdisciplinary collaboration and innovation transfer, which are essential for advancing sustainable soil management and achieving global sustainability goals.

Keywords: Living Labs, Soil Health, Agriculture, Agroecology, Sustainable Management, Interdisciplinary Networks

Acknowledgements

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SOIL DEGRADATION, REMEDIATION AND LAND MANAGEMENT IN THE SITES OF HISTORICAL ORE MINING AND PROCESSING – CASE STUDIES FROM THE SUDETES

Anna Karczewska [1], Agnieszka Dradrach [2], Katarzyna Szopka [1], Karolina Lewińska [3]

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Abstract

There are numerous remains of historical mining of metal(loid) ores in the Polish part of the Sudetes and in the Sudeten Foreland. For centuries, ores of copper, zinc, lead, nickel, tin, as well as arsenic, antimony and uranium have been mined there. In some of abandoned mines, well-preserved infrastructure has remained, i.e. shafts and adits, ruins of buildings, and various facilities that were used for mining and ore processing. All those relics of historical mining are the sources of knowledge on ancient mining technology. Therefore, many of such sites are currently being transformed into tourist attraction and play an important role in education. However, numerous mining heaps that remained in the sites of former mining activities are built of waste rocks that contain high or very high concentrations of potentially toxic elements. The soils that develop on those heaps and in their surrounding are often very rich in toxic metal(loid)s. This communication will present examples illustrating the scale of soil enrichment in toxic elements and the analysis of associated risk on several examples of historical mines. The susceptibility of these elements to mobilization, their phytoavailability and ecotoxicity will be taken into account. The real mobility and bioavailability of potentially toxic elements in rocks and soils in most of the sites examined in the Sudetes and their Foreland turned out to be relatively low, mainly thanks to the geological structure of ore deposits that often contain carbonate minerals. In some sites, however, where the rocks are acidic, a phenomenon of acid mine drainage and acid rock drainage (AMD and ARD) occurs on a local scale. A related threat to humans was assessed as very low because the mines are relatively distant from residential areas. The most serious environmental concerns are those associated with high concentrations of arsenic in soils and its possible release to water in the area of former arsenic mining and processing in Złoty Stok. Several factors that can affect arsenic mobility and the related risk to local communities will be analyzed and discussed. It should be stressed, however, that there is a negligible risk to potential visitors. Former ore mining areas have great tourist and educational values, and are also precious in terms of biodiversity and the potential for scientific research.

Keywords: metals, arsenic, solubility, heaps, environmental risk, tourist

SOIL DEVELOPMENT AND SPONTANEOUS VEGETATION GROUTH ON MINE RESIDUE DEPOSIT AT DIFFERENT CLIMATES IN NAMIBIA AND SOUTH AFRICA

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Abstract

The southern African Region is well known for its extensive mining sector comprising various commodities. Coal, gold, copper, zinc, lead, platinum group elements and other mineral resources have been mined here for many years under varying climate conditions, facing different challenges related to water supply and treatment during these activities. These mining and extraction activities produce vast amounts of mine residue material stored in a number of different ways. The mostly unsecured historical waste material can be the source of widespread groundwater and surface water pollution or harmful dust emissions. One important step to counteract these challenges is to establish a stabilising vegetation cover, with the chosen species varying according to the targeted end land use. For instance, vegetation may consist of crops or energy plants if used for agricultural purposes or, depending on soil quality and water availability, spontaneously colonising vegetation This cover may consist of crops or energy plants if used by agriculture, or, depending on soil quality and water availability, spontaneously colonising vegetation. The spontaneous vegetation can be supported to grow by initial irrigation and irrigation to overcome drought periods. The development of a spontaneous vegetation cover can support local biodiversity and can be understood as enhanced natural attenuation concept. However, a sustainable vegetation cover has to utilise species adapted to the local climate, and requires the development of a functional soil that can store sufficient amounts of plant available water providing nutrients, and maintain minimal contamination by pollutants.

In case of most mine residue deposits (MRD) the artificial development of soil layer is a prerequisite for a successful and sustainable plant cover. This soil can be taken from the surrounding environment but has a cost, as a compensation has to be found for the areas where the soil is removed from. Under a dry climate with arenosols or regosols soil material can be taken from vegetation free areas, but successful establishment of

vegetation will often require initial irrigation to overcome intensive drought periods. Therefore, soil water dynamics and the water balance of the MRD have to be monitored to be used as decision criterion for irrigation activities. Nevertheless, irrigation water must be made available for two primary purposes. First, it is necessary to provide irrigation after soil material has been filled on the MRD and vegetation growth has been initiated. Second, it is essential to utilize irrigation during periods of intense drought to ensure the protection of vegetation. Therefore, soil water dynamics and water balance of the MRD has to be monitored to be used as decision criterion for irrigation activities. Additionally, potential effects of climate change can be estimated through scenario-based simulations, supporting long-term strategies. Mine water, if not contaminated to a significant degree, can be used for that if often-occurring elevated salt contents, especially sulphates can be eliminated. Here, local materials can be identified and tested for sustainable and semi passive water treatment e.g. in filtration beds.

This development and realization of the concept described above is the aim of the research and development project WaMiSAR, Sustainable and Climate Adapted Water Management in Mining of the Southern African Region funded by the German Ministry of Research and Education. Here the participants developed a toolbox, i.e. a strategy to identify the best fitting method for revegetation of MRD (Fig. 1).

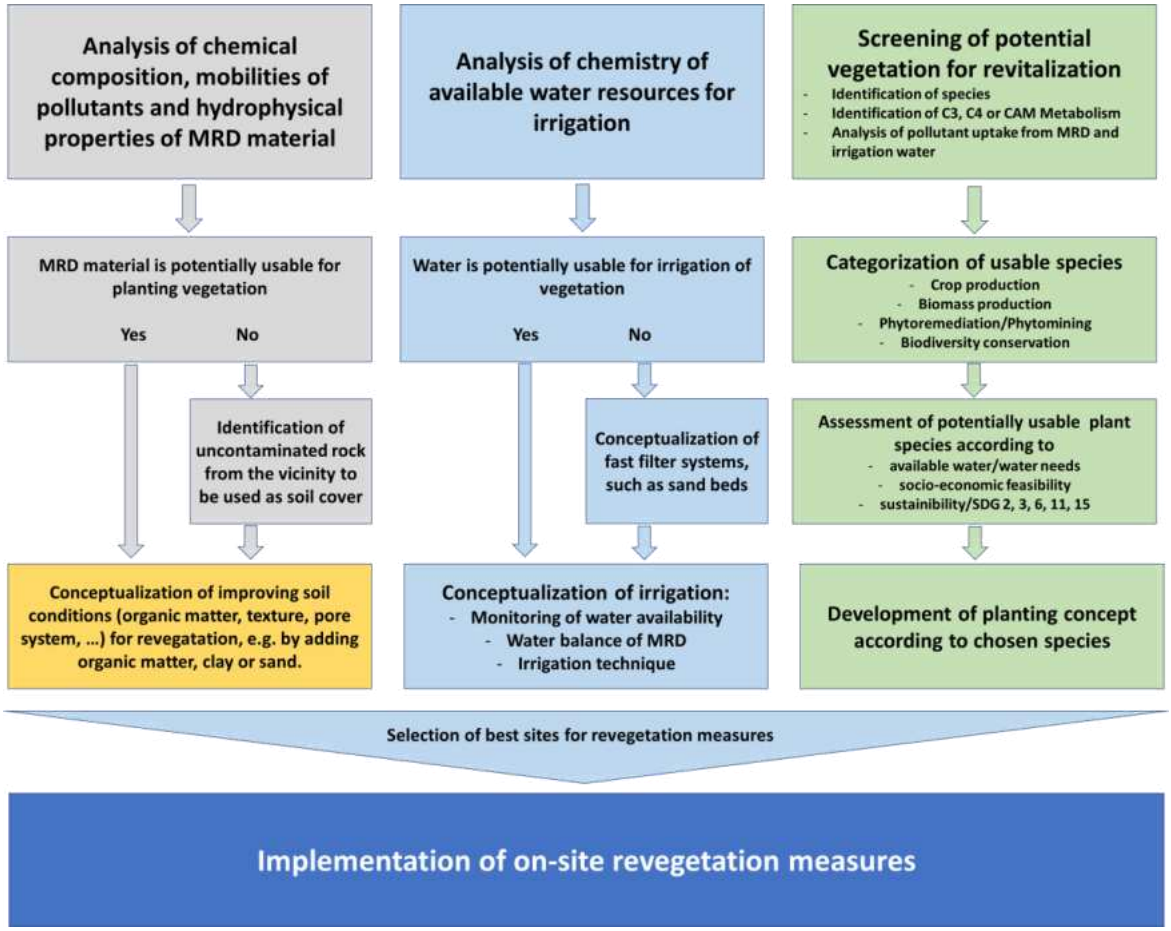

Fig. 1: Concept for revegetation of MRD.

In the WaMiSAR project three different MRD are in the focus, (i) in Rosh Pinah, Namibia, a zinc and lead mine, with approximately 35 mm rainfall per annum (ii) in Tsumeb, Namibia, copper mining and processing, with approximately 500 mm rainfall per annum and (iii) in Wonderwater, South Africa, a coal mine, with approximately 7500 mm rainfall per annum (Fig. 2). Here, the concept presented in Fig. 1 will be used to develop a sustainable vegetation to stabilize the mine waste.

Fig. 2: From left to right – MRD of Tsumeb, Rosh Pinah, Wonderwater

Keywords: mine residue deposits, revegetation, sustainable mine water use, soil water balance

AFRICAN DARK EARTHS ARE PATHWAYS TO ENHANCED SOIL CARBON, NUTRIENTS AND CROP PRODUCTIVITY IN GHANA AMIDST THE CHALLENGE OF HIGH MERCURY LEVELS

Caleb Ocansey[1], Vincent Logah[2], Edward Yeboah[3], Emmanuel Baidoo[2,3*], Joshua Gyindayu Abisah[2], Thomas Adjei-Gyapong[2] and Ben Banful[2]
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Abstract

Widespread degradation from artisanal and industrial mining continues to undermine ecosystem integrity, agricultural productivity, soil and water quality across Ghana's farm-forest zones. We propose a transdisciplinary approach to land restoration by integrating Artificial Intelligence for Sustainable Development (AI4SD) with Indigenous Knowledge Systems (IKS) and the ecological legacy of African Dark Earths (AfDEs). We are currently investigating the soil organic carbon dynamics, nutrients, heavy metal contents and crop productivity associated with 6 AfDEs in comparison to adjacent natural vegetation and smallholder farms in the forest-savanna ecotones of Ghana (≤ 100 cm). Key findings from AfDE research reveal that these anthropogenic soils are highly enriched in stable organic carbon, essential nutrients, and bioavailable minerals, and offer enhanced cation exchange capacity, water retention, and resilience to leaching and heavy metal toxicity. Both particulate organic matter and mineral associated organic carbon in AfDEs of smallholder farms are greater than in non-AfDEs. Aside Hg, all heavy metals studied (Mn, Zn, Cd, As, Pb and Ni) in the AfDE and non-AfDE at a depth of 0-20 cm were below the USEPA recommended thresholds for agricultural soils. Notably, without fertilizer inputs, AfDE soils produced significantly higher maize grain yields (~2.60 t ha^{-1}) and stover yields (~4.07 t ha^{-1}) which represented three- and six-fold increases compared to non-AfDE soils. These properties make AfDEs a valuable analogue for restoring the structure and fertility of mined lands. Our AI4SD project embeds machine learning algorithms within community-based monitoring systems, combining local climatic data, indigenous forecasting indicators and AfDE-informed soil amendments to model and predict ecosystem recovery. Drawing on current AI4SD field deployments and expanding to new districts, our system is supporting decision-making through farmer-participatory tools and predictive alerts to establish a scalable culturally embedded framework to regenerate degraded landscapes and guide sustainable land-use policies in Ghana and beyond.

Keywords: Artificial Intelligence, heavy metals, nature-based solutions and weather forecast.

Acknowledgements AI4SD Project - Ambassade De France Au Ghana

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European Joint Programme– C-arouNd Project.

REMATRIATING THE SOIL BY INTEGRATING INDIGENOUS KNOWLEDGE SYSTEMS WITH MODERN SOIL SCIENCE FOR SUSTAINABLE LAND CARE: CASE STUDIES FROM SOUTH AFRICA

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Abstract

Soil degradation and ecological grief is widespread, not only in South Africa, but across the globe and threatens agricultural sustainability. It is not surprising therefore that the control, remediation and reclamation of soil degradation is receiving urgent attention. In many African cultures, the soil is viewed as a source of life, identity and communal well-being. The soil is often revered as a life-giving force, connecting people to the land, ancestors and the natural world. This sacred relationship influences the practices of sustainable land management. The care and management of soil are often tied to traditional knowledge and communal responsibilities. It emphasizes restoring land stewardship practices that align with indigenous values and worldviews and are deeply rooted in a holistic understanding of the natural world, where soil is seen as a living entity that is central to the interconnectedness of all life.

In this paper, three case studies from South Africa are used to highlight the value of traditional practices by combining them with scientific advancements to develop sustainable land management practices that are culturally relevant and ecologically sound and have successfully rehabilitated and restored degraded soils. The first case involves an old age practice where farmers integrate trees and shrubs with crops and livestock in an agroforestry system. Our scientific measurements have shown that the practice enhances fertility through leaf litter fall and root decay which adds organic matter to the soil. The system supports biodiversity and enhances soil structure, water retention and reduces erosion. The second case is the practice of mixed intercropping where diverse crops are grown on the same land at the same time. Scientific results have shown higher soil nitrogen levels due to nitrogen fixation by leguminous species and improved crop yields. The third case study describes the incorporation of organic materials such as manure, wood ash, earthworm casts, termitaria and crop residues as amendments. Results of scientific measurements have shown significantly higher concentartions of soil nutrients (N, P exchangeable Ca, Mg, K), pH, soil water retention and enhanced soil structure due to these amendments. The paper concludes by proposing models for collaboration between scientists and indigenous communities, emphasizing mutual respect, knowledge exchange, and co-creation of innovative sustainable practices that enhance soil health for future generation.

Keywords: Soil degradation, land stewardship, sustainability, worldviews, soil health

SOIL AGGREGATE STABILITY AND ORGANIC CARBON STOCKS IN PANDAMANTENGA PLAINS, BOTSWANA: TOWARDS SUSTAINABLE LANDUSE

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Abstract

Soil aggregate stability and organic carbon (OC) storage are key biogeochemical indicators of soil health and its ability to function within an ecosystem including providing sustainable and just medium for the transformation of agri-food systems. Soil aggregation protects OC, and its disruption through natural or human activities can lead to OC loss. While land use impacts soil quality, its effect on aggregate stability and OC stocks in Botswana's agriculturally important Pandamantenga alluvial plains is not well understood. This study investigated how different land uses (arable land, grassland exclosures, natural exclosures, and pastures) influence these properties. Soil samples were collected at three depths (0-15, 15-30, and 30-45 mm) and sieved into six aggregate size classes (>4.75, 4.75-2.00,2.00-1.00,1.00-0.50, 0.50-0.25 and <0.25 mm). Routine laboratory methods were used to analyze soil properties, including particle size, bulk density, pH, electrical conductivity, exchangeable bases, OC content, and aggregate-associated carbon. Aggregate stability was assessed using wet sieving, calculating indices like water-stable aggregates (WSA), mean weight diameter (MWD), geometric mean diameter (GMD), and R0.25. The soils were classified as Vertisols. Results showed that land use significantly affected soil structure and carbon dynamics. Natural exclosures exhibited the highest MWD and GMD, followed by grassland exclosures, pastures, and arable land. WSA varied by land use and aggregate size, with arable land having more WSA in smaller fractions and less in larger ones. Pastures had more mid-sized aggregates, while natural exclosures were dominated by larger aggregates. R0.25 remained consistent across land uses due to high clay content. Larger aggregates (>0.25 mm) contained more OC and showed a strong positive correlation between stability and OC, highlighting the importance of aggregate stability for carbon sequestration and soil health by minimizing carbon loss and enhancing SOC storage. Natural exclosures had the highest OC stocks, particularly in larger aggregates, followed by arable land. Grassland exclosures and pastures had lower OC stocks. These findings will inform strategies to improve sustainable agricultural productivity, soil conservation, and carbon management in the face of climate change.

Keywords: Carbon sequestration; Vertisols; Water stable aggregates; Soil conservation; Tillage.

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EFFECT OF BIOCHAR APPLICATION ON HEAVY METAL SOLUBILITY AND SPECIATION IN SOILS AND SUBSTRATES AFFECTED BY METALLURGICAL ACTIVITY IN BULGARIA

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Abstract

The effect of biochar (BC) on heavy metals solubility and speciation and soil properties in the vicinity of Aurubis-Pirdop Cu smelter, the former Kremikovtsi steel plant and Asarel-Medet Cu plant were studied. Maximum permissible concentrations (MPC) were exceeded for Cu (319 – 2645 mg/kg) around the Aurubis-Pirdop Cu-smelter. Lead (899 mg/kg) exceeded 2 - 15 times the MPC and arsenic, between 3 and 6 times for the soils (pH 7-8) in the area of Kremikovtsi steel plant. Incubation experiments were performed with different rates of biochar (BC), 1, 5, 10 and 20 % in a *Climatic Chamber with Phytotron System*. Metals were measured in water extracts and speciation was performed by *Visual Minteq*. For the acidic Cu-contaminated soils incubation time and BC rates led to a total decrease of Cu and Pb, while dissolved organic carbon (DOC) and pH increased with BC addition. Ion speciation in the non-treated acidic soils was represented by the free Me^{n+} ions, while with increasing incubation time and BC rates, FA_2M and M-FA gel fraction species were predominant. In the acidic soils of higher Cu contents the total soluble Cu concentration decreased by ~ 70%, while free Cu species concentrations decreased to ~ 4%. For the neutral to slightly alkaline soils around the steel plant, metal concentrations decreased with time, due to transfer to more resistant soil pools. Cation exchange capacity, exchangeable Ca and pH increased from BC application, while electrical conductivity decreased, except in the Asarel waste embankments. The samples from the Asarel site include rock mass containing Cu minerals from the "Oxide Embankment" treated with sulfuric acid, and samples of rock mass from the mine overburden, "Western Embankment". The samples are characterized by extreme acidity, pH (H_2O) 3.0 - 3.9. The electrical conductivity (EC) is high and varies from 0.98 to 3.86 $mS.cm^{-1}$. The RedOx potential is negative and exchangeable AI, reaches 34.7 $cmol.kg^{-1}$. Cu exceeds the MPC (3-9 times) and Cd, 1.2 – 2 times. The geochemical modeling indicates predominance of free Me^{n+} ions and $Me_2^{n+}(SO_4)_n$ complexes in the untreated samples and prevalence of hydroxy and mixed complexes $/FA_2AlOH(aq)$ and $/FA_2Al^+(aq)$ of AI (85%) and $/FA_2Cu(aq)$, $/FACu^+(aq)$ and $/FA_2CuOH(aq)$ for Cu.

Biochar incorporation has a positive effect both on Cu and other metals concentrations and metal speciation in the investigated soils, mainly by increasing the

share of less toxic and bioavailable organic species in the soils of Aurubis-Pirdop and Kremikovtsi soils. In the Asarel dump embankments free Cu^{2+} species and $CuSO_4^0$ complexes decreased by 50% in the 20% BC ameliorated and limed substrates, while the other Me^{n+} species were still prevailing at pH 5.9-6.4 variants. Significant correlations were obtained between plant concentrations of Cu, Mn and Zn and H_2O/NH_4NO_3 soluble metals in the acidic soils of Aurubis-Pirdop and Medet areas, and with % OC in a multiple regression.

Keywords: biochar, heavy metals concentration, speciation, organic complexes, soil, mine substrates

BIOCHAR APPLICATION INFLUENCES PAHs FRACTIONATION IN SOILS

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Abstract

Persistent organic pollutants (POPs), including polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides (COPs) undergo various processes in soils over time, including sorption/desorption and diffusion in soil pore spaces and strong binding by soil components. Studies on soils from areas historically contaminated with POPs indicate that despite high total contents of the contaminant target groups, no harmful effects of pollutants on living organisms are observed, and the use of remediation treatments rarely brings satisfactory results. These phenomena are explained by the low environmental availability of pollutants what indicates low amounts of easily desorbing pollutant fractions. Literature data usually indicate on SOM as the main factor influencing fractional composition of POPs in soils. The study was aimed at the evaluation of fractional composition of POPs in soils as influenced by biochar amendment. Three soils varied with physic-chemical properties were used in the laboratory experiment. The experimental series included soils enriched with 5% of biochar (m/m) (B1-B3) and without biochar amendment (control soils; C1-C3). All of soils were spiked with six PAHs: Fl, Fen, Ant, Pir, Ch and BkF dissolved in dimethylochloride and after solvent evaporation, watered up to 55% of WHC and kept in the controlled temperature 20°C±2 for 7 and 360 days. Soil moisture during the experiment was kept constant. Three POPs fractions were determined. Tenax-TA extraction method was applied to analyse easily desorbing and slowly desorbing fractions, while not desorbing fraction (residual) was calculated as the difference between the total POPs content and the sum of desorbing fractions. PAHs were determined using GC-MS apparatus.
Biochar application generally reduced the amount of easily desorbing PAHs fractions but their share (as related to the total PAH content) was influenced by time and PAH properties. Enrichment of soils with 5% of biochar did not affected PAH slowly desorbing fractions but increased the amount of PAHs remaining in soils after 7 and 360 days as compared to control soils.

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ASSESSING THE DYNAMICS OF ORGANIC CARBON AND NUTRIENTS IN SOIL AGGREGATE SIZE FRACTIONS UNDER TILLAGE AND NO-TILLAGE PRACTICES IN OXISOL OF CAMEROON

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Abstract

This study examines the effects of tillage practices—Conventional Tillage (CT) and No Tillage (NT)—on aggregate size distribution, along with organic carbon and nutrient dynamics in Oxisols from Dschang. Soil samples were collected from two depth horizons (0-10 cm and 10-20 cm) to evaluate variations in soil structure and its implications for carbon retention and nutrient availability.

The aggregate distribution analysis revealed significant differences influenced by tillage practices. NT exhibited a higher percentage of intermediate-sized aggregates, indicating a more favorable aggregate structure for carbon storage. Moreover, NT showed elevated Mean Weight Diameter (MWD) and Geometric Mean Diameter (GMD), demonstrating enhanced aggregate stability and soil structure, crucial for maintaining organic carbon levels.

Organic carbon chemistry assessment highlighted varying contributions of organic carbon fractions between CT and NT, with NT consistently maintaining higher organic carbon levels, particularly in the 0-10 cm layer, reflecting the benefits of reduced soil disturbance. Additionally, total nitrogen content, carbon stock (C-stock), and C/N ratios were generally more favorable under NT, signifying improved soil health and microbial activity.

This study emphasizes the role of tillage management practices in shaping soil organic carbon dynamics, aggregate stability, and overall soil health. The findings suggest that no-tillage practices are superior for enhancing carbon storage and soil fertility, making it a vital approach for sustainable agricultural management, especially in regions like Dschang. Overall, the exploration of organic carbon chemistry provides insights essential for developing effective soil conservation strategies and promoting sustainable agricultural practices.

Keywords: Tillage-Aggregates- Oxisol- Nutrients Availability- Organic Carbon

Acknowledgements: This study was supported by the New Zealand Global Research Alliance on Agricultural Greenhouse Gases Agreement No 2023-EJPSOILS-TILSOILC-UD.

IMPACT ON THE QUALITY AND SUSTAINABLE USE OF SOILS FROM THE IMPLEMENTATION OF LARGE-SCALE SYSTEMS FOR THE PRODUCTION AND STORAGE OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES

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Abstract

The conducted research is related to establishing the state of the soil cover on the territory of an existing photovoltaic plant for the production of electrical energy. The soils of the areas planned for the construction of a photovoltaic park were also investigated. The obtained results were compared with the characteristics of the soils from the region of the studied sites.

The conducted field and analytical studies on the territory of an existing photovoltaic park testify to the lack of significant impact of electricity production on the state of the soil cover. Conditions are created to preserve soils from intensive cultivation for an extended period of time, with minimal or no application of pesticides, herbicides and fertilizers and no treatments. This is also related to preserving the health of the soil and restoring its fertility.

The need to conduct field studies, prepare studies and prepare annual monitoring reports regarding the short-term, medium-term and long-term impact of the implementation of large-scale systems for the production and storage of electrical energy from renewable energy sources (RES) on ecosystems and biodiversity is proven, as well as on the quality and sustainable use of soils.

The study of the soils in the territories adjacent to the photovoltaic parks provides an opportunity to track the impact that the exploitation of the sites has on the soil cover and to plan actions to overcome the negative impacts.

Examining the state of the soil cover before the construction of a photovoltaic park allows for proper planning of the program for monitoring the objects and drawing up a system of measures to preserve and improve soil fertility on the territory of the objects.

Keywords: photovoltaic plant; photovoltaic park; renewable energy sources; soil health.

SULPHUR CONTENT IN RIBWORT PLANTAIN, SOIL AND AIR IN THE ENVIRONMENT OF THE MOLVE GAS FIELD, CROATIA

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Abstract

Sulphur is an essential macronutrient for plants that differs in the way it is absorbed, its functions within the plant, its mobility and the possible symptoms of deficiency or toxicity. The natural balance of this element in soil and plants can be disturbed by anthropogenic influences, e.g. emissions from gas refineries. The Central Gas Station (CGS) Molve, part of the Croatian Gas Energy System Podravina in the northern part of Croatia, refines natural gas from the surrounding wells. Scientists from a multidisciplinary research team have been monitoring the impact on various components of the ecosystem such as air, water, soil, plants, forests and wild and domestic animals for the last five years (2018-2022). The monitoring points are carefully selected representative sites with different soil types, water regimes and wind directions in the vicinity of the CGS. This paper presents the results of the total sulphur (TS) content in ribwort plantain (*Plantago lanceolata* L.) and soil and the mass concentrations of gaseous S-compounds in air (H_2S, mercaptans (R-SH) and SO_2). The measurements were carried out in the vicinity of the CGS, including at 5 sites close to boreholes that are possible emission sources: Molve 9 (M9), M10, M11, M12, CGS. The paper also shows the total annual atmospheric sulphur deposition ($S\text{-}SO_4$) at the Bilogora monitoring station. Sampling of H_2S, R-SH and SO_2 in the air was carried out twice a year, in a 30-day period during the warmer season (summer) and a 30-day period during the colder season (winter or late fall). Surface [(0-3) cm] and subsurface [(3-8) cm] soil samples as well as the leaves and stems of ribwort plantain were also taken twice a year, in spring and fall. Depending on the soil type, sampling depth and site, the mean individual measured values of TS in the soil were between 10 $mgkg^{-1}$ and 2960 $mgkg^{-1}$. The lowest average values (in relation to the sites) were found on Regosol acric M9 with 397 $mgkg^{-1}$ (at 0-3 cm) and 366 $mgkg^{-1}$ (at 3-8 cm) and the highest average values on the Gleysol vertic, M12, 1188 $mgkg^{-1}$ (at 0-3 cm) and M9, 1022 $mgkg^{-1}$ (at 3-8 cm). Depending on sampling site and season, the mean values in ribwort plantain ranged from 1330 $mgkg^{-1}$ to 4600 $mgkg^{-1}$, with an overall mean value of 2511 $mgkg^{-1}$. The average annual atmospheric TS deposition ranged from 2.56 $kgha^{-1}$ to 6.38 $kgha^{-1}$ with a mean value of 4.33 $kgha^{-1}$ and a very strong negative correlation to today (compared to time; r=-0.87). Depending on the sampling location and season, the mean monthly mass concentrations of H_2S in the air varied between 0.92 μgm^{-3} and 2.29 μgm^{-3}, R-SH between 0.37 μgm^{-3} and 1.37 μgm^{-3} and SO_2 between 0.43 μgm^{-3} and 3.40 μgm^{-3}. In Croatia, the Ordinance on Air Pollutant Levels (OG 72/20) prescribes concentration limits (LV) based on quality of life (odor annoyance) for 24-hour concentration averages (5 μgm^{-3}, 3 μgm^{-3} and 125 μgm^{-3} for H_2S, R-SH and SO_2, respectively) and the frequency of permissible exceedances during the calendar year ($\leq$ 7 times for H_2S and R-SH and $\leq$ 3 times for SO_2). During the five-year monitoring of H_2S, R-SH and SO_2, the LV was never exceeded in winter or summer. The sulphur content in the plant material of ribwort plantain and in the soil is within the tolerable range.

Keywords: Energy System Podravina, monitoring, H_2S, R-SH, SO_2, *Plantago lanceolate,* atmospheric deposition.

MODIFIED SPENT COFFEE GROUNDS AND BIOCHAR REMEDIATION OF HEAVY METAL CONTAMINATED URBAN SOILS IN GLASGOW.

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Abstract

Heavy metals contamination is one of the biggest threats to both urban and agricultural soils. Earlier remediation methods were prioritized on efficacy; however, today's innovative approaches are evaluated on sustainability, cost, and multifunctionality. The abundance and therefore, low cost of the waste coffee biomass makes it a great choice for use in soil remediation as it also fits into the waste reuse component of sustainability. The use of coffee grounds for remediation is not new its effectiveness has been demonstrated to date. This research explores whether additional modifications can improve the efficacy, particularly for multi-metal contaminated soils. The goal of this study was to investigate how modification by pyrolysis and oxidation using hydrogen peroxide, could help immobilise heavy metals in multi-contaminated soils. The spent coffee grounds (SCG) were split into three main treatments, raw SCG, SCG Biochar (by pyrolysis at 550°C), and then each of these modified with hydrogen peroxide to create Raw SCG modified and SCG Char modified. These were applied to 500g of soil in column experiments at rates of 1% and 3% respectively, these were replicated five times and included control columns. The soils and treatment mixtures were allowed to incubate under laboratory conditions at 20°C for 28 days, Leachate was collected every 7 days and analysed for pH, EC, DOC, DIC, and ICP-OES. On day 29, Pak choi seeds were planted in the columns and left to grow for 60 days. The collected leachate and the end-of-experiment soils are currently being analysed, and results will be available at time of the presentation. Preliminary indications show an increase in plant size with each modification from the raw SCG, with the biggest plants from the treated columns in the modified biochar treatments.

Keywords: soil contamination, spent coffee, biochar, heavy metals, remediation, circular economy

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RESTORING SOIL HEALTH AND P DYNAMICS THROUGH LESS INTENSIVE LAND USES: GRASSLAND ESTABLISHMENT AND REWILDING

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Abstract

Intensive agricultural often leads to significant losses of soil organic matter (SOM) and organic P due to accelerated mineralization, resulting in the predominance of recalcitrant SOM compounds and the depletion available P. Since organic P is a key medium and long-term source of plant-available P, its loss means a serious threat to agricultural sustainability. Understanding how land use and management changes can restore soil health is therefore critical. This study explored the long-term dynamics of soil P under two less intensive strategies: a) converting cropland to grassland and b) rewilding croplands in two distinct environments: NW Spain (oceanic temperate climate) and SE Siberia (sharply continental climate).

Both grassland establishment and rewilding led to a slow but steady recovery of SOM content and quality and in organic P, primarily in the form of P-monoesters and diesters. This indicated that transitioning from intensive cropland to less intensive land use or practices can partially offset initial nutrient losses and improve P-uses efficiency. While the restoration of P levels and their distribution to pre-disturbance states remains a long-term process, the study highlights the vital role of soil conservation practices in maintaining soil nutrient cycles and enhancing agroecosystems' resilience.

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EFFECTS OF AMENDMENTS ON THE RELEASE OF ANTIMONY AND LEAD FROM SPIKED SOILS UNDER DIFFERENT MOISTURE CONDITIONS

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Abstract

Lead (Pb) and antimony (Sb) are common co-contaminants in shooting range soils, exhibiting contrasting mobility behaviours that challenge remediation efforts. This study evaluates the effectiveness of three soil amendments: oxalic acid phosphate rock (OAPR), calcium phosphate (CP), and compost combined with ferric sulphate (CO+Fe), in immobilizing Sb and Pb under two moisture regimes (80% and 100% WHC). Soils were spiked with either Pb-Sb alloy or soluble salts and incubated for 12 months. Samples from the experiment were collected after 2 days, 1 month, 7 and 12 months from the day the amendments were introduced. Extractions of 1M NH_4NO_3 and 0.05M EDTA were used to determine the effect of the amendments on soil and release the easily soluble and bioavailable forms. ICP-MS analysis and extraction showed that CO+Fe significantly reduced Sb mobility, particularly in salt-spiked and waterlogged soils. OAPR and CP effectively stabilized Pb, which confirms previous studies (Rasool et al., 2021). However, under reducing conditions, Fe-based amendments may increase Sb mobility due to Fe oxide dissolution. Soluble salts significantly increased the availability of Sb and Pb in comparison to alloy-spiked soils, especially under waterlogged conditions (100% WHC), due to increased dissolution and redox-induced transformations. PCA revealed strong correlations between pH, Eh, as well as WHC and element mobility. The study confirms that soil moisture content and redox potential critically impact amendment efficacy. Remediation strategies must therefore be tailored to local hydrological and geochemical conditions.

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VARIABILITY IN THE DISTRIBUTION OF MAJOR AND TRACE ELEMENTS AND POLYCYCLIC AROMATIC HYDROCARBONS IN THE SURFACE LAYERS OF FOREST SOILS

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Abstract

In a temperate climate zone, the outermost part of the forest soil profile is an organic-O horizon, which consists of various subhorizons, including an organic litter subhorizon (Ol) and an organic fermentative-humic subhorizon (Ofh). The structure of the subhorizon Ofh, resembling tangled tobacco fibers, acts as a 'natural sponge' for selected trace elements such as Cd, Hg, Pb, Zn, as well as polycyclic aromatic hydrocarbons (PAHs). Consequently, their concentrations are significantly higher in this subhorizon compared to the adjacent (sub)horizons. To verify this hypothesis, 130 soil samples (65 from the subhorizon Ofh and 65 from the lower horizons A/AE) were collected from five forest areas located in south-central Poland. All samples were analyzed for pH, electrical conductivity (EC), cation exchange capacity (CEC), soil organic matter (SOM) content, total carbon (TC), total nitrogen (TN), and concentrations of Ba, Ca, Cd, Cu, Fe, Hg, K, Mn, Pb, S, Ti, Zn and 16 PAHs. The results confirm that the subhorizon Ofh exhibited a lower pH ($4.7_{Ofh}/5.4_{A}/5.4_{AE}$) compared to the underlying horizons and 2 to 4 times higher concentrations of C, N, and S ($32.4_{Ofh}/9.84_{A}/3.18_{AE}$ %; $1.01_{Ofh}/0.34_{A}/0.11_{AE}$ %; $2077_{Ofh}/956_{A}/534_{AE}$ $mg \cdot kg^{-1}$). Significantly higher concentrations were also recorded for Cd, Hg, and Zn (in $mg \cdot kg^{-1}$): Cd – $1.38_{Ofh}/0.839/0.255$; Hg –$0.203_{Ofh}/0.187_{A}/0.055_{AE}$; Zn – $146_{Ofh}/90.0_{A}/43.3_{AE}$. However, this trend was not observed for Pb, which predominated in the horizon A ($60.7_{Ofh}/112_{A}/41.4_{AE}$) (Dołęgowska et al., 2024). The highest average concentrations of total PAHs were also observed in the subhorizon Ofh ($1547_{Ofh}/1103_{A}/109_{AE}$ $\mu g \cdot kg^{-1}$). However, the percentage distribution of 3-, 4-, 5-, and 6-ring PAHs in the total PAH content varied depending on the analyzed (sub)horizon. The 6-ring PAHs predominated in the subhorizon Ofh, while 4- and 5-ring PAHs in the horizon A, and 3-ring PAHs in the horizon AE (Dołęgowska et al., 2025). These findings suggest different retention mechanisms across the analyzed (sub)horizons. Understanding these dynamics is crucial for assessing environmental contamination. The results may be a starting point for further research on the potential use of the subhorizon Ofh as a geoindicator of soil quality in relation to selected trace elements and PAHs.

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GENETIC SOIL CLASSIFICATION AS A BASELINE FOR THE ASSESSMENT OF SOIL DEGRADATION IN SERBIA UNDER CLIMATE CHANGE

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Abstract

In this work we utilized the existing soil maps in Serbia for soil degradation assessment under current climate and climate change. Soil classification used in Serbia belongs to genetic systems. This system clearly recognize soil genesis, state of evolutionary stadium, and future soil development, with or without possible anthoropogenic measures. It also allowed us to categorize soils by their vulnerability to soil degradation. In this work Aridity Index (AI) was applied for the assessment of risk of desertification, whereas the extreme precipitation indicator (EPI) was applied to assess the risk of soil erosion by water. The risk of soil degradation was also assessed using combined effects which considered the overlaying of climate and land–related degradation factors, which are directly related to soil genesis and evolution. Soil management was not considered in the analysis. Average surface air temperature increase in Serbia for more than 1.5°C (2000–2020) compared to the 1961–1990 period, whereas precipitation change its annual distribution toward the colder period, and its intensity toward more extreme events and reduction of moderate events. Climate layers considered AI and EPI were prepared based on EOBS dataset for current conditions, and RCP8.5 scenario for future conditions, using EURO-CORDEX ensemble of models selected as in other national risk assessment studies and tools, Climate Change Adaptation Programme of Serbia, Digital Climate Atlas of Serbia. Topographic layer was created from 90 m DEM, and the ranks were assigned based on slope percentage. Vegetation layer was prepared using CORINE land cover 2006 database and the ranks were assigned based on vegetation vulnerability. Soil map layer was derived 1:50000 soil maps, with aggregated soil mapping units. Higher vulnerability rank was assigned to Solonchaks, Solonetz, Arenosols, Sirozems, Rankers, Lithosols, and Calcomelanosols. The risk of desertification was identified to be higher in southern and eastern Serbia. The risk of soil degradation caused by extreme precipitation increased significantly comparing current (6.6% of the area under higher risk) and future conditions (56% of the area under higher risk). The risk of soil degradation considering combined effects indicate that in the 2001–2020 period, 14% of the territory was found at very and extremely high risk levels, whereas for 2041–2060 period, 25% of the territory will be at very and extremely high risk levels. This kind of methodology could be improved using better quality soil maps, improvement of topographic factor, or utilization of remote sensing for vegetation analysis. Soil management layer could be also prepared in order to improve the assessment. Nevertheless, the obtained results could be compared with some existing soil degradation metrics, like land productivity dynamics. This national level risk assessment could be a guiding reference for the selection of priority areas, and planning of preventive measures can be done after the local level improved assessment and field observations.

Keywords: Soil degradation, Risk, Soil classification, Aridity index, Extreme precipitation index

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COMPARATIVE ANALYSIS OF SOIL DEGRADATION AND SOIL STRUCTURE IN CROPLANDS AFFECTED BY EROSION AND SOIL DEHYDRATION TREATED WITH A BIOLOGICAL SOIL CRUST FORMING ALGAL CULTURE

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Abstract

Climate-related land degradation and desertification threaten around half of EU member states. In Hungary, wind and water erosion affects 2.3 million hectares of land. One of the most important indicators of soil degradation is the water retention capacity of the soil. Therefore, the primary objective is to maintain or increase it. Due to their adaptation to extreme enviromental conditions, soil algae can survive in drought-stricken areas. With their contribution, biological soil crusts can be formed on the top layer of the soil. Soil crusts can stabilize the surface of the soils, enhance the water retainment, thus indirectly contributing to the settlement of higher order vegetation. Therefore, soil algal cultures can be applied to inoculate desert, steppe and eroded areas. The basis of our demonstrated soil crust-forming technology is the *Klebsormidium bilatum* filamentous green soil algae developed by Albitech Biotechnology Ltd. In 2020, we examined the impact of algal inoculation on brown forest soils in sloping arable land. We measured the extent of soil degradation by artificial rainfall simulation, carried out soil moisture, aggregate stability, macro- and microporosity, and soil crust structural tests. According to porosity tests and soil moisture measurements, the formed algae crusts on the soil surface had a beneficial effect on the soil structure. The more favourable micromorphological structure also caused the deeper layers of the soil more aerated, which had a positive effect on the hydrological properties of the soil. The established algae layer and the improvement in soil structure contributed to a reduction in soil losses caused by water erosion. As a result, we also experienced an increase in yields of corn and spring barley in sloping areas treated with soil algae.
The project was supported by MKI-2018-00034 grant and the National Multidisciplinary Laboratory project NKFIH-872 of the National Research, Development and Innovation Office, Hungary

Keywords: crusts, *Klebsormidium*, erosion, agriculture

DYNAMICS, MOBILITY AND SOURCES OF HEAVY METALS AFTER BIOCHAR ADDITION IN CONTAMINATED AGRICULTURAL SOILS AROUND A COPPER SMELTER

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Abstract

Heavy metal contaminated agricultural soils from the vicinity of Aurubis-Pirdop copper smelter in Bulgaria were investigated for the status of mobile and bioavailable forms (0.01M $CaCl_2$ and 1M NH_4NO_3 extraction) of Al, Ba, Cd, Cu, Ni, Pb and Zn after amelioration with increasing doses of biochar (BC) 1, 5, 10 and 20% w/w for a period of 6 months. For the precise monitoring and evaluation of the BC induced changes, an incubation experiment was set with four selected soils in the area, characterized by low pH and organic carbon content. Generally, with the increasing of BC dose the mobility of the studied elements significantly decreased. Copper extractable forms in 0.01M $CaCl_2$ decreased from 75.3 mg kg^{-1} in T1 Control variant at the initial stage of the experiment to 19.3 mg kg^{-1} in T1 20% BC at the end of the study. Nevertheless, for some sites and for copper, as the primary pollutant in the area, bioavailable concentrations, as assessed by 1M NH_4NO_3 method were still above the trigger values after 6 months from amelioration with BC. In the more acidic soils, the effect of BC application on the immobilization of the metals was most pronounced. A significant tendency of decrease of mobile concentrations over the course of the experiment ("aging effect") was noticed. Biochar in a dose of 20% w/w, had a strongest influence on the physicochemical properties of the soils: pH increased by 0.4 – 0.7 units, exchangeable Al decreased by 54 - 70%, and total organic carbon (TOC) increased 1-3 times compared to the controls. The PCA and cluster analysis prove that the mobile forms of metals Cu, Cd, Pb and Zn were complexed with dissolved organic carbon (DOC) and were of predominant anthropogenic origin in the surface soils, while, e.g. Ba and Ni are mobilized from pedogenic sources.

Acknowledgements

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SEPARATION OF MICROPLASTICS FROM SOIL - A RECOVERY EXPERIMENT

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Abstract

Microplastics can enter the soil as a product of the degradation of plastic waste and sewage sludge, river terrace flooding, roadside pollution, plastic mulching or other agricultural practices. Currently, there is no standardized approach to the challenging tasks of extraction, identification, and quantification of microplastics in soil. However, some relatively well-established methods look very promising. Density separation is the most common method for extracting microplastics particles (up to 5 mm in size) from the soil and sediment samples. The aim of the current study was to validate a two-step procedure based on the publication of Nuelle et al. (2014) for extracting microplastics from soil samples. A recovery experiment of spiking soils and sand with known quantities and types of microplastics was performed. The soil samples were taken from the surface layer of virgin Calcic Chernozem and Cambisol with high content of organic matter. Plastic particles of less than 5 mm in size were produced by grinding products made of polyethylene terephthalate (PET), polypropylene (PP), high density polyethylene (HDPE), low density polyethylene (LDPE), polyvinyl chloride (PVC), and expanded polystyrene (EPS). Equal quantity (4.5 mg microplastics/kg soil) of each type of microplastics was added to the soil samples (200 g grinded soil, sieved through 2 mm sieve). Three wetting-drying cycles were performed to facilitate inclusion of microplastics into soil aggregates. After the separation of the microplastics, they were weighed and photographed. The types of microplastics were verified by the Fourier Transform Infrared Spectrometer (FTIR).

The adopted procedure will be used to determine the microplastics contamination along the Iskar River in Sofia fields, as well as in some roadside hot spots.

Keywords: microplastics, density separation, laboratory experiment, wetting-drying

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MICROBIAL BIOFORTIFICATION OF ORGANIC AMENDMENTS FOR MANAGING ORGANIC CONTAMINANTS IN AGRICULTURAL SOIL

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Abstract

Beyond their widely acknowledged role as soil conditioners capable of preserving soil fertility and maintaining soil health, recycled biowastes such as compost, digestate and biochar are attracting increasing attention for use as effective carriers of microbial consortia into arable soils. This role provides additional environmental benefits such as mitigation of adverse effects on plants grown in polluted soils (Kabir et al., 2023; Wang et al., 2023).

This work contributes to investigate the feasibility of enriching four widely used soil amendments (biochar from forest trees, solid digestate from mixed feedstock, digestate-derived compost and vermicompost) with selected soil microbial consortia (consisting of naturally occurring fungal and bacterial species) able to tolerate the presence of four contaminants of emerging concern (CECs), namely penconazole, S-metolachlor, bisphenol A, and 4-nonylphenol). These matrices will constitute stable and functionally active microbially-enriched biosorbents (Me-BIOSORs). Five plant growth promoting (PGP) microorganisms were isolated from environmental sources which were studied together with seventeen bacterial strains isolated from two commercially available microbial bio-stimulant formulations. All isolates were tested *in vitro* for their ability to grow under increasing concentrations (0, 0.2, 0.5 and 1 mg L^{-1}) of each selected CEC. Preliminary results highlighted a good tolerance of the isolated microbial strains to the contaminants within the tested concentration range. Future steps involve the testing of the CECs-tolerant strains for their antagonistic activity, and the selection of potential candidates for preparing microbial consortia. The selected consortia will be combined with BIOSORs to evaluate their ability to survive and remain metabolically active in these media, thus obtaining promising biofortified BIOSORs to be tested in soil-plant systems in a microcosm scale experiment.

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FACTORS AFFECTING VARIABILITY OF SOIL QUALITY INDICATORS UNDER EROSION CONTROL AND TRADITIONAL TILLAGE

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Abstract

The main limiting factor for the fertility of Epicalcic Chernozems on sloped terrains is their susceptibility to soil erosion due to their structural deficit and low water stability of aggregates. The aim of the study was to evaluate the effectiveness of soil conservation tillage systems in controlling soil erosion and improving soil quality, as well as to assess the sensitivity and sustainability of soil quality indicators in moderately eroded Epicalcic Chernozem. We hypothesized that early detection of change in soil properties could be done by widely used biological, physical and chemical indicators of soil quality. Since we found a large variation of these parameters, we focused on sensitivity and sustainability of a complex of soil quality indicators under constant application of erosion control tillage systems. A 3 years' experiment with wheat and maize in rotation was conducted on Epicalcic Chernozem on slope of 5°, including conventional tillage along the slope (T0), conventional contour tillage (T1) and minimum tillage, with the inclusion of a cover crop, after wheat before maize, applied as green manure (T2). The soil microbial, chemical and physical properties were measured, twice in a growing season in two depths. In the first year, there was no improvement of many of the studied indicators. In the second and third years, a higher amount of total organic carbon (TOC) was reported in the erosion control treatments. The soil microbial biomass carbon content increased in T2, in the second year (by 0.67 mg 100 g^{-1} under wheat) and in the third year (by 3.74 mg 100g^{-1} and 4.80 mg 100 g^{-1} under wheat and maize, correspondingly). Enzyme activity is consider to be a sensitive indicator for the status of soil quality. An increase in the activity of peroxidase and polyphenol oxidase was reported from the first year, while the activity of protease, urease, alkaline phosphatase and ß glucosidase increased in the second year and more significantly in the third year. Under the minimum tillage treatments, the available forms of macroelements and electrical conductivity slightly decreased in some periods, due to including of cover crop. The water stability of soil aggregates had a well pronounced seasonal dynamic. In autumn the water stability of soil aggregates in the surface 0-5 cm layer was higher than in spring. This tendency was better exhibited in the dryest 2023 year. An increase of the plant available capacity (PAWC) under T2 was observed in 0-10 cm soil layer in April under maize. In autumn, the erosion control technologies mitigated the subsoil compaction provoking a decrease of PAWC in T0. In conclusion, the applied erosion control technologies in the wheat-maize rotation lead to a stable increase in enzyme activity, microbial biomass and TOC and soil physical parameters compared to the conventional crop cultivation along the slope.

Keywords: soil water erosion, conservation tillage, cover crop.

Acknowledgements The authors acknowledge funding of research activities received from the National Science Fund under grant agreement № КП-06-Н76/2 2023 (project "Integration of satellite derived and ground-based data for soil water balance components and crop cover into models for assessment of agroecological risks and agricultural practices for their mitigation")

ASSESSMENT OF SOIL WATER BALANCE COMPONENTS UNDER EROSION CONTROL AGROTECHNOLOGIES VIA EXPERIMENTAL DATA AND SIMULATION MODELS

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The soil-protecting crop rotations and conservation tillage practices aim to reduce the water run-off and soil losses on sloping terrains, and hence to increase the infiltration rates and soil water storage. Using experimental data and simulation models, the purpose of this study is to evaluate the dynamics of soil water balance components during a four-year field experiment with winter wheat-maize crop rotation and cover crops. The field experiment was performed on sloping terrain from 2021 to 2024 year on moderately eroded Epicalcic Chernozem in the region of Ruse, North Bulgaria, under wheat-maize crop rotation and 3 variants of agro-technologies: conventional tillage applied up-and-down the slope (T0), conventional contour tillage (T1) and crop specific erosion control contour tillage (T2). The latter includes minimum tillage, direct sowing and cover crop after wheat harvest and its incorporation as green manure before maize. The simulations were performed by two models - the dual Kc approach of the FAO56 (Allen et al., 1998) and SWAT model. The consolidation of experimental data and model predictions of the soil water balance, allowed to trace the effect of the studied agro-technologies and crop rotation sequences on water saving on sloping terrain. The inclusion of water stress compensation function improved significantly the predicted soil water content during dry period especially under maize which is a drought sensitive crop. The SCS method for estimation of surface run-off was used to complete the information on annual base. The applied models allowed to achieve reasonable estimates for the dynamic of run-offs during non-monitored autumn and early spring periods and acceptable coincidence between crop transpiration and yields under different agro-technologies.

Keywords: soil water balance, water erosion, drought, evapotranspiration

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ASSESSMENT OF CROP PRODUCTION POTENTIAL OF SOME ARABLE SOILS FROM BĂRĂGAN PLAIN

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Abstract

The objective of this study is to evaluate the production potential of arable soils in the Bărăgan Plain, within the area of the localities Valea Argovei, Nicolae Bălcescu, and Gurbănești, Călărași County. The studied lands are geographically located in the Romanian Plain, specifically in the Southern Bărăgan Plain subunit. The climate is temperate continental, with an average annual temperature of 10.5°C and an average annual precipitation of 450-500 mm.

A total of 46 plots were analyzed, from which 86 soil samples were collected for chemical determinations at depths of 0-20 cm and 30-50 cm. Additionally, 34 samples were taken to determine soil texture, and from 11 sites, samples were collected in two repetitions to assess hydro-physical properties.

The classification of the land in terms of quality was conducted using the agricultural land rating method, under natural conditions, based on 18 eco-pedological indicators representing climate, soil, and land parameters.

The studied soils belong to the Cernisols class. This class is represented in the analyzed area by the cambic chernozem soil type, which is dominant in the region, covering interfluvial field surfaces and terrace platforms.

The soil cover in the studied area has high fertility potential, with favorable physical and chemical properties for agricultural crops. The soils are well-drained, well-supplied with nutrients, generally have a loamy-clay texture, a moderate-to-good humus reserve, and a slightly acidic to neutral pH. According to Romania's soil monitoring system (a 16x16 km network) carried out between 2000 and 2008, all soils in the studied area were classified as second-quality class for arable land use.

Out of the 46 analyzed sites, 32 were classified as second-quality class for arable use, while 14 sites exhibited limiting factors that reduced their land rating, placing them in the third-quality class for arable use. The limiting factors that led to a lower rating included climate conditions (high air temperatures and low precipitation—although the average annual precipitation remained the same, its periodicity changed, negatively impacting production), soil texture, porosity, pollution, humus reserve at a depth of 0-50 cm, and the deep groundwater level.

In conclusion, the reduction in soil productivity potential was caused both by natural factors and by irresponsible use of arable land, leading to the degradation of soil properties through compaction, structural destruction, depletion of the humus reserve, and acidification of the plowed layer.

PHYTOTOXICITY OF SOIL PORE WATER IN SOILS STRONGLY CONTAMINATED WITH COPPER AND LEAD

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Abstract

Adverse environmental effects caused by soil contamination with heavy metals, in particular copper (Cu) and lead (Pb), depend not only on their total concentrations, but also on the forms in which they occur and the possibility of their release into pore water. The study assessed phytotoxicity of soil pore water acquired from soils neighboring with the Legnica copper smelter, polluted with Cu and Pb, that were limed several decades ago to immobilize toxic elements, which are currently susceptible to slow acidification. Soil samples were collected at three distances (I, II, II) from the smelter. They had the texture of silt loam and were slightly acidic. Their total concentrations of metals were 370, 1230 and 8250 mg/kg Cu and 150, 480 and 1640 mg/kg Pb, respectively. Prior to an incubation experiment, soils were adjusted to two pH ranges (4.0-4.5 and 6.8-7.0) and enriched with one of two additives: beech forest litter or mineral N fertilizer (ammonium nitrate). The soils were incubated for 7 and 21 days at constant moisture (80% of water holding capacity). Soil pore water was obtained using MacroRhizon samplers to measure the concentrations of Cu and Pb. Phytotoxicity of soil pore water was assessed in a Phytotox bioassay with white mustard (Sinapis alba L.) based on the inhibition of seed germination and reduced elongation of seedlings' roots and shoots. The study confirmed that in alkaline pH conditions, Cu and Pb were effectively immobilized, regardless of the additive used. Cu concentrations measured in soil pore water after 21 days of incubation ranged from 0.09 to 5.87 mg/l in all limed soils, while they reached 8900 mg/l in the acidified III soil treated with the mineral fertilizer. The results of phytotoxicity bioassay were strongly correlated with Cu and Pb concentrations in soil pore water. The results provide a good reference base for further experiments aimed at predicting soil phytotoxicity in Cu and Pb-contaminated soils that will be subjected to different management.

Keywords: urban soils, soil indicators, soil health, trace elements

MACRONUTRIENTS AND BUFFER CAPACITY OF TWO SOIL TYPES UNDER BEAN CULTIVATION (PHASEOLUS VULGARIS L.)

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Abstract

Beans (Phaseolus vulgaris L.) are an essential legume crop, valued for their nutritional profile and ability to contribute to sustainable agricultural systems. This two-year study evaluated the impact of biological products on soil quality and bean productivity under rainfed conditions on two soil types in Bulgaria: Fluvisol (Sofia) and Luvic Chernozem (Ruse). The tested treatments included the commercial products Naturalis (based on Beauveria bassiana ATCC 74040) and Softgard (chitosan-based biostimulant), applied individually and in combination, along with three active strains of the entomopathogenic fungus Beauveria bassiana. Soil chemical indicators—including total organic carbon (humus), pH, available phosphorus and potassium, total and mineral nitrogen—were measured across two growing seasons (2023–2024).

In Fluvisol, the initial high fertility observed in 2023, with phosphorus reaching 61.8 mg/100g and potassium 58.1 mg/100g, was supported by strong buffering capacity (CEC 17.4–18.7 Meq/100g) and humus levels exceeding 4%. By 2024, a significant reduction in nutrient content and humus (to 1.66–2.70%) was observed, highlighting gradual organic matter depletion and phosphorus fixation even under stable pH (6.9–7.0). Despite this, the soil maintained its buffering performance with only minor changes in CEC and total acidity, suggesting resilience to biological loading.

In Luvic Chernozem, nutrient depletion was more pronounced in 2024, with phosphorus dropping to 4.6 mg/100g and signs of acidification (pH < 6.0) accompanied by exchangeable aluminum appearance (up to 0.3 Meq/100g). Although CEC values remained high (T8.2 > 29 Meq/100g), the emerging acid reaction indicates that prolonged biological stimulation may gradually exceed the soil's buffering threshold. This underscores the importance of pH stabilization strategies, such as liming, to prevent phosphorus inaccessibility and microbial stress.

Across both soils, the highest bean yields were recorded in variants treated with Beauveria bassiana strains. Overall, the results demonstrate that while biological agents enhance productivity and short-term soil fertility, sustained application requires careful management of soil buffering systems to preserve long-term soil health and nutrient availability. This highlights the strategic role of monitoring and balancing biological and mineral inputs in sustainable legume-based systems.

Keywords: beans, biological products, nitrogen, phosphorus and potassium availability

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DO CREOSOTE-IMPREGNATED POLES CREATE A REAL SOURCE OF PAHS IN SOILS ON HOP PLANTATION?

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Abstract

For many decades creosote was considered as very effective fungal and insect wood conservation agent used also for supporting constructions outd in vineyards, orchards and hop plantations. Creosote is a mixture of hundreds of chemicals with the dominated fraction created by polycyclic aromatic hydrocarbons (PAHs). Among PAHs are potential carcinogens, including the well-known benzo(a)pyrene. High concentrations of PAHs in soils can indicate the negative effects towards microorganisms and plants. Therefore, information on contaminant loadings in soils are important for application of holistic framework for sustainable risk-based land management including low-input remediation actions. The aim of the study was to determine PAHs concentration in soils on hop plantations as influenced by creosote-impregnated poles and then indication of bioremediation actions for hop producers. Thirty-five hop plantations were selected to the study. All of them were located in Lubelskie voivodeship, Poland. Regarding Polish regulation on historical contamination (Dz.U. 2016 poz 1395) these with area increasing 1ha were divided into three sections, therefore 75 sampling sites (sections) were finally recorded. Soil samples were collected from the upper soil layer (0-25 cm) in the 25 cm distance from the pole (n=75) and in the row between two adjacent poles (n=75). Soil samples after passing the preparation phase were analysed for texture, pH in water (pHw) and in 1 mol KCl L-1 pH_{KCl}), organic carbon (Corg), total nitrogen (Nt) and total exchangeable bases (TEB). Content of 10 PAHs: Naf, Ant, BaA, Ch, BbF, BkF, BaP, DAnt, BPer, IndP was determined by the accredited laboratory. Soil samples with individual PAH content exceeding national permissible level for agricultural soils were accounted as contaminated. The majority of soils (80%) were classified as silt loam with average silt content of 62% and average pH_{KCl}, Corg, Nt and TEB values of 6.1;1.40%; 0.15% and 15.4 cmoll(+) $100g^{-1}$, respectively. In 34 sites PAHs concentration in soils collected in the vicinity of poles exceeded the permissible levels. Maximum BaA, Ch, BbF, BkF and BaP concentrations accounted for 5.660 mg kg^{-1}, 6.490 mg kg^{-1}, 6. 450 mg kg^{-1}, 2.120 mg kg^{-1}, and 3.260 mg kg^{-1}, respectively while in the rows remained uncontaminated. Results indicated that creosote-impregnated poles can constitute the PAH source for soil but only in their close vicinity and pollutants are not spread for entire plantation. Implementation of low-impact remediation actions including on-site phytoremediation or bioremediation of PAH contaminated soils can be implemented during hop production or after the poles removal.

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SELECTED INDICATORS OF SOIL HEALTH IN VARIOUSLY CONTAMINATED URBAN GARDEN SOILS

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Abstract

Soil contamination with heavy metals in urban areas poses a significant environmental hazard, particularly in regions with historical or ongoing industrial activities. These areas are often polluted with metals such as Pb, Cu, Cd, and Zn, which can be absorbed by plants, posing risks to both ecosystems and human health. Contamination of garden soils is also dangerous to soil organisms, reducing their abundance and biodiversity. To measure and assess changes in soil properties and function, a number of indicators of soil health have been developed.. Thus, systemic approaches based on different kinds of indicators (physical, chemical, and biological) in assessing urban soil health should be discussed. This study focusses on the urban gardens soils in Wrocław (Poland), where elevated levels of potentially toxic elements were identified. The aim of this study was to evaluate the possibility of using standard chemical tests and ecotoxicological tests to assess the contamination of urban garden soils. Soils were collected from three complexes of urban gardens located in Wrocław (Poland), which were selected based on the high risk of local heavy metal contamination related to historical or current industry, high road traffic, and the flood that occurred in 1997. Total concentrations of selected trace metals (Pb, Zn, Cd, Cu) were determined by soil digestion with "aqua regia. Potentially and easily soluble forms of metals were extracted in dilute nitric acid according to the ISO standard (17586: 2016) and in 1M ammonium nitrate according to the ISO standard (ISO 19730: 2008), respectively. The standardized Ostracode test with *Heterocypris incongruens* was used as an ecotoxicological bioassay. The test involved incubating organisms for 6 days to assess the impact of contaminants on their growth. The study revealed that Zn, Cu, Pb, Cd concentrations in soils exceeded limits permitted by Polish regulations in several soil samples. Despite high total metal concentrations, easily soluble forms of metals were low, highlighting that total metal content does not fully reflect the environmental risk. The highest inhibition of the growth rate of *H. incongruens* was observed in the soil most strongly contaminated with potentially toxic elements, in particular lead. Pb was identified as the primary contributor to growth inhibition of test organisms, showing strong correlations observed for both total forms and those available in NH_4NO_3 with ecotoxicity. This bioassay could be an important screening tool in the assessment of soil health and toxicity caused by soil contamination with heavy metals and metalloids.10.

ARSENIC BIOACCESSIBILITY IN SOILS OF ZŁOTY STOK ALLOTMENT GARDENS

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Abstract

Arsenic (As) contamination resulting from historic mining in Złoty Stok, southwestern Poland poses significant health risk to local populations. Złoty Stok boast of two allotment complexes which are usually cultivated as family gardens for food crops and serves as family recreational or vacation spots. However, these plots could be a point of human exposure to As. Previous studies have focused on the estimation of total As concentration (TA) and the mobile/easily soluble fraction of As which could lead to overestimation or underestimation of human health risk assessment. The aim of this study was to determine the bioaccessible fraction of As using two different oral in-vitro bioaccessibility assays. Also, the performance of these two methods was compared. California Bioaccessibility (CAB) and Simplified Bioaccessibility Extraction (SBET) methods were employed in this study to simulate the human gastrointestinal system. Soils samples from the allotment gardens were collected from a depth of 0-20cm, pretreated and sieved through a 2mm and <250 µm mesh sieve stainless steel sieve. TA in the soil was analyzed according to USEPA 3051A procedure using the 2mm sieved soil samples. In-vitro bioaccessibility assay was performed according to CAB and SBET procedures using soils with particle size <250 µm. The results indicates that TA in all the samples exceeded 300 mgkg-1 and the highest concentration was 730 mgkg-1. Bioaccessible As fraction through CAB ranged from 61-93% of TA while that of SBET ranged from 43-66% of TA. Across all sites, CAB method consistently extracted significantly higher percentage TA.

Keywords: arsenic, bioaccessibility, soil, allotment garden, Złoty Stok

SOIL CHEMICAL INDICATORS OF POTENTIALLY TOXIC ELEMENT MOBILITY UNDER RIVERINE PRESSURE IN SENSITIVE AREAS

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Abstract

Industrial and mining activities in regions such as the Srednogorie frequently lead to the contamination of river systems, which in turn exerts long-term pressure on adjacent soil ecosystems. The Topolnitsa River is a typical example of a fluvial system under anthropogenic impact with the potential to transport various harmful substances. The ecological state of river is crucial because the watershed serves as a primary irrigation unit in Southern Bulgaria. The region relies heavily on these water sources for agricultural purposes, and maintaining their health ensures sustainable farming practices and overall environmental balance.

This study explores how the content and composition of soil organic matter and the soils' buffering capacity influence the mobility of potentially toxic elements, determined through sequential extractions by $CaCl_2$, NH_4NO_3, and EDTA. Soils were sampled from four locations along the Topolnitsa River and its main tributaries Medetska, Zlatishka and Bunovska - covering sites with varying degrees of contamination. Site T1 was classified as uncontaminated, T2 and T3 as highly contaminated, and T4 as moderately contaminated.

Higher organic matter content and more favorable humic-to-fulvic acid ratios (HA/FA) were associated with lower metal mobility. In contrast, strongly and moderately contaminated sites have significantly higher extractability of Cu and Pb, particularly in EDTA, emphasizing the potential for transfer into biological and aquatic systems. The most critical site was T3, combining high total and mobile concentrations of Cu and Pb with low organic matter content.

The results highlight the need for targeted management strategies, including enhancement of buffering capacity and maintenance of around neutral pH, to limit the mobilization of metals. The assessment follows the thresholds set by Regulation No. 3/2008 on soil contamination and Regulation No. 18/2009 on irrigation water quality. This study presents need of integrated approach for assessing environmental risk from anthropogenic impact by using soil properties and water quality as indicators of PTE behavior in ecosystems (Kabata-Pendias, 2011; Alloway, 2013).

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SUSTAINABLE BIOFERTILIZERS FROM LIVESTOCK WASTE: OVERCOMING BARRIERS TO SOIL RECLAMATION IN DEGRADED ATLANTIC LANDSCAPES

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Abstract

The growing global demand for mineral fertilizers, especially P, coupled with the dependence on non-renewable and geographically concentrated sources, has led to a sustained increase in their prices and a growing concern for security of supply. The complementary projects AGRORES and AGROMANURE aim to develop and evaluate a sustainable, accredited system for managing livestock manure and agro-industrial waste by producing high-quality biofertilizers. This approach addresses environmental challenges while improving soil quality in degradation-prone areas, focusing on overcoming technical and economic barriers in Spain's Atlantic region. The projects explore cost-effective, energy-efficient solutions tailored to local agri-food management (e.g., manure production, soil types), geographic conditions (climate, topography), and socioeconomic factors (e.g., land distribution).

Pilot activities in NW Spain (Galicia) have yielded a nutrient-rich digestate from livestock organic waste, mainly slurry and dairy residues, with show low heavy metal concentrations and complementary nutrient contents and organic matter quality. The anaerobic digestion enhanced phosphorus availability (31P NMR) and the resulting digestate showed higher nutrient contents and superior organic matter quality (13C NMR and DSC-TG) compared to raw residues. Field tests on degraded soils show an increase in grass yield versus mineral fertilizers or raw slurry, attributed to the readily available P in the digestate, underlining its potential for sustainable restoration of grassland soils.

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INFLUENCE OF LONG-TERM BIOCHAR APPLICATION ON CO_2 AND NO_2 EMISSIONS ON FLUVISOL

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Abstract

The use of biochar improves soil properties and crop yields, as well as reduces greenhouse gas emissions. The aim of this study was to evaluate the long term effect of biochar added on CO_2 and N_2O emissions on a Fluvisol. The study was conducted in the experimental field of Tsalapitsa village, where biochar and nitrogen fertilization were applied 4, 5, and 6 years ago. Variants of the experiment started in 2019 with two doses of BC (5 and 10 t/ha) and two rates of nitrogen fertilizers (130 and 260 kg/ha). In 2023 another experiment was set up on the same field, with only biochar applied at 10 and 15 t/ha. In 2023 and 2024, greenhouse gases (CO_2 and N_2O) were measured during the vegetation of the crops grown (wheat and barley).

There was no consistent trend observed on the studied greenhouse gas emissions in response to biochar applied to soil and crops in the long term. However, it was found that after 2-6 years of biochar application insignificant changes in N_2O and CO2 emissions were observed during the growing season at the different rates of biochar added.

A positive correlation was found between CO_2 emissions, total organic carbon (TOC), soil reaction (pH), mineral nitrogen content (Nmin), soil moisture and the rates of biochar applied. The N_2O greenhouse gas emissions were not related to TOC, CO_2, Nmin content and nitrogen fertilization rate.

In conclusion, application rates and time scale of biochar added and nitrogen fertilizers were not the main factors affecting soil CO_2 and N_2O emissions, but other controlling factors, such as temperature, precipitation, and soil characteristics, also played a role.

Keywords: biochar, greenhouse gas emissions, long term experiment.

SINCE ANCIENT TIMES PANAGYURISHTE REGION HAS BEEN ASSOCIATED WITH MINING

The Panagyurishte ore region covers the southern slopes of the Sashtinska Sredna Gora and occupies an area of about 600 km^2. Part of it is the **Assarel**-Medet ore field, where the largest reserves of Cu and copper-pyrite ores in Bulgaria are concentrated.

The Panagyurishte region was included in the geological surveys in 1900-1907. In 1922, surveys were carried out along the Elshishka River in the Gradishte area. In the 1930s, ore-hunters headed to the Srednogorie mountain range north of Panagyurishte. On July 7, 1931 with a letter from the Ministry of Trade, Industry and Labour, the boundaries preserved by Ivan Trenchev with all rights and obligations were transferred to Nikola Bakardzhiev from the town of Panagyurishte.

The geological exploration region of "Panagyurishte" was established on January 1, 1954. The first explored deposits were "Elshitsa" and "Radka". Until the mid1950s, only some pyrite and Cu mineralizations were known in the area north of Panagyurishte, and were underestimated as deposits of industrial importance. The first assessment was made by Anton Ushev, Stoyka Chipakova and Krum Angelkov, who in 1955 justified the need for geological exploration activities in the Medet river area.

The detailed study of the "**Medet**" deposit was carried out in 1956-1962, and the "Medet" Mining and Processing Complex (MPC) was established (1964-1994), the largest open-pit copper mine at that time in Europe and the **3rd in the world**. At the end of 1968, the **"Assarel"** Cu deposit was discovered and had been explored until 1976.

"**Assarel"** is the name of a locality in the mountain of **Sashtinska Sredna Gora,** with an altitude of about 1000 meters, located 11 kilometers Northwest of Panagyurishte and 90 km east of the capital Sofia.

The hydrothermal Cu deposit of **"Assarel"** is of copper-porphyric type, located 12 km from the deposit "Medet" in the Panagyurishte ore region. It was formed during the late Cretaceous and the main ore minerals are chalcocite, pyrite, chalcopyrite, bornite and covellite, with an average Cu content of 0.45%.

Ore samples from the "Assarel" deposit.

Construction of the "Assarel" mine and enrichment plant.

After a detailed geological survey, **on January 1, 1976,** the experimental mining section **"Assarel"** was created. This marked the beginning of the construction of the "**Assarel"**, Mining and Processing Complex in which the traditions of the "Medet" MPC were developed and the most modern technologies, high-performance equipment and unique company know-how are implemented.

The first dig of the "**Assarel"** mine was founded on **May 7, 1976**. Since 1977, the extracted ore has been processed in the then reconstructed Medet Mining and Processing Plant. Since 1986, the chief and later executive director **Eng. Lachezar Tsotsorkov**, organized the decisive stage of the construction of the mine and the new enrichment plant. Under his leadership, worldwide experience was applied and many design-oriented solutions were improved.

The **"Assarel"** mine and the enrichment plant for the production of Cu concentrate "**Assarel**" are the two main production facilities of the "**Assarel**-Medet" Mining and Processing Complex, (JSC).

The modern infrastructure of the largest Bulgarian mining company for open-pit mining and processing of Cu ores also includes a water treatment facility, a system for micro-biological leaching of Cu, a cyclic-flow technology for the transport of mining mass, installations for sorption and electrolysis of Cu, modern purification facilities and administrative and other buildings.

On September 30, 1989, the first facilities of the **Assarel** Enrichment Plant began operating with an initial capacity of 7.5-10.5 million tons of annual Cu ore extraction and processing. The first ton of Cu concentrate was extracted from the new plant on October 1, 1989.

On the basis of the newly constructed capacities of the **Assarel** Mining and Processing Complex, the **Assarel-Medet** Technological Mining and Processing Complex was established in **1986,** the largest Bulgarian mining company for open-pit mining and processing of Cu ores.

On December 6, 1989, the produced quantities of concentrate were sent to Pirdop Mining and Processing Plant, which is the date of the official introduction of the Assarel Mining and Processing Plant.

Being the first, the largest and leading Bulgarian mining company for open-pit mining and enrichment of copper and other ores, the "**Assarel-Medet"** JSC produces and offers high-quality Cu concentrates and cathode copper. The company has unique mining machines and the most modern flotation equipment from leading world manufacturers. The main mining equipment of the "**Assarel"** mine includes modern drilling equipment with a chisel diameter of 250 mm, 130-ton dump trucks and electric excavators with a bucket volume of 17 m^3. The first flotation machines of the latest generation for the Northern hemisphere with a volume of 160 m^3 are operating in the "**Assarel"** enrichment plant, automated systems for management and control of the technological processes have been implemented in the "**Assarel"** mine and the enrichment plant, which guarantee high efficiency and productivity.

"Assarel-Medet" JSC is the winner of dozens of national and international awards in the field of investments, innovations, ecology, management, company culture, occupational safety and corporate social responsibility.

The company's team encompasses1200 employees at "**Assarel**-Medet" AD and 400 employed in subsidiaries and joint ventures.

The company implements and creates the best production and management practices in the mining industry. This was once again confirmed in 2004, when the implementation of a large-scale modernization project began, amounting to over 100 million USD. Investments in the renewal of equipment and technologies are the basis of high production results, record for the history of the company in the Bulgarian mining industry.

Academic teams from **"Nikola Poushkarov" Institute of Soil Science** (now **Institute of Soil Science, Agrotechnologies and Plant Protection ISSAPP**) have been working in long-term cooperation with **"Assarel-Medet**" **JSC** on various projects.

The project we are currently working on is entitled: "**Effect of biochar application on the immobilization and bioavailability of heavy metal and other pollutants in technogenic soils**", funded by the Bulgarian National Science Fund, Ministry of Education and Science (2023-2026).

Over the years, the innovative spirit of **Assarel e**mployees has been reflected in the company motto: **"To go first means to go on time!"** and the humane motto:

"FROM NATURE FOR PEOPLE, FROM PEOPLE FOR NATURE"