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PROCEEDINGS

TwinSubDyn Summer School

on Sustainable organic amendment applications from a soil and ground water management perspective

-learning, training, and knowledge exchange activity-

02-06. June 2025, Novi Sad, Serbia

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Editors Prof. Dr. Srđan Rončević, University of Novi Sad, Faculty of Sciences
Prof. Dr. Snežana Maletić, University of Novi Sad, Faculty of Sciences
Dr. Tamara Apostolović, University of Novi Sad, Faculty of Sciences
Dr. Marko Šolić, University of Novi Sad, Faculty of Sciences
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Event summary

The Summer School is organized as part of the horizon Europe TwinSubDyn project. Summer School, designed to provide a deep dive into the transformative effects of organic soil amendments on soil organic carbon, nutrient dynamics, and contaminant behavior in the soil subsurface, with profound implications for groundwater quality. This comprehensive program offers participants a unique blend of theoretical lectures and hands-on demonstrations, guided by leading experts in the field. Key Objectives: (1) Explore the intricate relationships between organic soil amendments and soil quality, focusing on carbon sequestration, nutrient cycling, and contaminant mitigation in the subsurface environment. (2) Provide attendees with practical insights and methodologies for implementing organic soil amendments to address soil and groundwater challenges effectively. (3) Foster a collaborative environment for knowledge exchange and networking among participants and experts in soil science and environmental remediation. (4) Empower early-stage researchers with essential soft skills training, including experimental design, statistical analysis, scientific writing, and navigating the landscape of ESR career development, targeting appropriate calls to participate in and how to do impactful research. During the summer school, participants will have the chance to showcase their work in their respective fields through abstract submission, and oral presentations or poster sessions.

Topics of interest

1. Long term stability of organic soil amendment,
2. Nutrient management of organic soil amendments;
3. Carbonising sewage sludge or biosolids to remove pollutants;
4. Fate and transport of emerging pollutants in organic soil amendments,

General training topics dedicated to the early-stage researchers:

5. Field experiments design and statistics;
6. Scientific writing training;
7. Round-table breakout sessions ECR career development.

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POSTER PRESENTATIONS

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TOPIC 1.

Long Term Stability of Organic Soil Amendment

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Keynote lecture

BIOCHAR AS A CDR TECHNOLOGY: WHERE DOES IT STAND AND CAN IT BE COMBINED WITH OTHER CDR METHODS?

***Claudia Kammann*[1]*, Susanne Hamburge[1], Johannes Meyer zu Drewer[2], Nikolas Hagemann[2]**

[1]*Department of Applied Ecology, Hochschule Geisenheim University, Germany, *claudia.kammann@hs-gm.de*

[2]*Ithaka Institute, Freiburg, Germany*

My presentation will touch on X fields within the broad topic of biochar/pyrolysis: (1) Its use, status, and inclusion as a negative emission technology for carbon dioxide removal (CDR), why we need the latter, and where voluntary markets, trading platforms, and Measurement, Reporting and Verification (MRV) schemes stand today; (2) An overview over the results from > 200 metastudies on biochar-CDR, largely on biochar's use in agriculture, and what we have learned via research over the past 15 years; and (3) Results from some of my own projects, some of which are part of Germany's national research efforts to gain knowledge and understanding of different CDR technologies, their economic and environmental chances, challenges, and drawbacks, and, in our case, synergies between two of them, the use of biochar and rock powder (enhanced weathering) in soils.

In the following, I give some insights into (1) and (3).

Biochar use in agriculture, landscape architecture, and in building materials can deliver net CDR when the biomass used for pyrolysis is sustainably sourced. Currently, a new IPCC methodology is developed where biochar will be included to develop national inventory methods (comparable to the national GHG inventory methods) for quantifying national CDR budgets. Countries such as Denmark have included biochar-CDR (PyCCS, pyrolysis for carbon capture and storage) into their national strategies. For CDR trading, five well-adopted voluntary MRV schemes exist that grow rapidly, which I will compare based on a study carried out by the International Biochar Initiative (IBI). Moreover, trading platforms and C-sink accounting have developed rapidly so that Biochar-CDR currently dominates the world's leaderboards on actually delivered (and not just promised) CDR.

The German Ministry for Education and Research funds 10 research consortia that deal with exploring different carbon dioxide removal (CDR) techniques, their potentials, and side effects, under the umbrella of the CDRterra research program (https://cdrterra.de/). Our consortium "PyMiCCS" (Pyrolysis and Mineral Weathering for Carbon Capture and Storage) explores the synergetic potential of combining (1) pyrogenic carbon capture (biochar) and (2) enhanced weathering (EW); both can theoretically (3) enhance soil organic carbon (SOC besides the C in biochar), and thus increase (4) biomass carbon capture (BCC). These nature-based solutions have high TRLs and can be implemented globally by using low- as well as high-tech approaches. PyMiCCS focuses on potential synergies or cancelling-out effects of combining biochar and rock powder (EW), either pre- or post-pyrolysis. Co-pyrolysis may increase the C-yield in rock-enhanced biochar (RE-biochar) when a feedstock is pyrolyzed with rock powder [1,2] while biochar has overall positive effects on several agronomically relevant soil parameters [3,4]. PyMiCCS applies a cascade of iterative experiments and analyses from the lab to the field scale, with and without soils and plants, to produce the data needed to parameterize global models for C-sink potential analyses and to assess the economic feasibility. Experiments investigate the separate and combined CDR potential of EW (i) under controlled conditions; (ii) in soils without

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plants and (iii) in soils with plants (greenhouse and under controlled field conditions) and in (iv) field experiments in the tropics (Kenya). Experiments in (iii) include measurements of environmental side effects (nitrate leaching, N_2O emissions) that can impact the net CDR balance compared to the use of single applications of both rock powder or biochar. I will report results from the first 1.5 to 2 years from the four experimentally-working subgroups of the PyMiCCS consortium (University of Hamburg with two consortium subgroups on EW and soil processes), Ithaka Institute (PyMiCCS-products, C-fixation, tropical field experiments in Kenya), and Geisenheim University (greenhouse and controlled-field experiments in the presence of crop plants, including N losses).

Keywords: Carbon Dioxide Removal, Biochar, Enhanced weathering, Nitrate leaching, Nitrous oxide

References:

[1] Buss, W., et al., *Mineral-enriched biochar delivers enhanced nutrient recovery and carbon dioxide removal.* Comm. Earth Environ. 2022. **3**: 67.
[2] Mašek, O., et al., *Potassium doping increases biochar carbon sequestration potential by 45%, facilitating decoupling of carbon sequestration from soil improvement.* Sci. Rep. 2019. **9**: 5514.
[3] Schmidt, H.-P., et al., *Biochar in agriculture – A systematic review of 26 global meta-analyses.* GCB Bioenergy, 2021. **13**: 1708-1730.
[4] Beerling, D.J., et al., *Potential for large-scale CO_2 removal via enhanced rock weathering with croplands.* Nature, 2020. **583**: 242-248.

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Keynote lecture

BIOCHAR AND LIME APPLICATION EFFECT ON SOIL ORGANIC CARBON CONTENT UNDER DIFFERENT TILLAGE SYSTEMS ON ACID SOIL: A 7-YEAR FIELD EXPERIMENT

***Boris Đurđević*[1]*, Irena Jug[1], Bojana Brozović[1], Danijel Jug[1]**

*[1]Faculty of Agrobiotechnical Sciences Osijek, University of Josip Juraj Strossmayer in Osijek, Vladimira Preloga 1, Osijek, Croatia, *bdurdevic@fazos.hr*

Biochar has the potential to improve various chemical, biological, and physical properties of soil, and it is often recognized for its ability of long-term carbon sequestration. When used in combination with lime, biochar can serve as an effective amendment for extremely acidic soils. Soil organic carbon (SOC) sequestration, however, is influenced by several agrotechnical factors, particularly tillage practices. This study aimed to assess the effects of different tillage systems–conventional tillage (ST), deep conservation tillage (CTD), and shallow conservation tillage (CTS) –as well as liming (without lime - LN, and with lime - LY) and biochar application (40 t ha^{-1}) on SOC content in Stagnosol soil in eastern Croatia. The average SOC value was 1.60%, significantly affected by the time span (F=27.82) and tillage treatment (F=5.19). Significant interactions between Year × Tillage (F=2.44) and Year × Tillage × Liming (F=2.35) were observed. The highest SOC was recorded under CTS LN in 2019 (2.03%) and the lowest in 2023 (1.22%), with a coefficient of variation of 12.95%. Across all years, CTS showed the highest average SOC (1.66%), while ST had the lowest (1.56%), with statistically significant differences except between ST and CTD. After biochar application, SOC exhibited an almost linear increase (38.32%) until 2019, followed by a less pronounced decrease thereafter. Most of the differences in SOC values over the years were statistically significant. Our findings suggest that SOC content increased in the short and mid-term but began to decline after 2019. Conservation tillage, particularly CTS, was found to promote greater SOC accumulation compared to conventional practices, demonstrating its potential for enhancing soil carbon sequestration.

Keywords: Biochar, Soil organic matter, Conservation tillage

Acknowledgements: This work has been fully supported by Croatian Science Foundation under the project "Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation – ACTIVEsoil" (IP-2020-02-2647).

APPLICATION OF SYNTHETIC SOIL IN FTIR SPECTROSCOPIC INVESTIGATION OF SOIL COMPOSITION

***Branko B. Kordić*[1]*, Slobodanka B. Dragojević[2], Branislav D. Jović[1]**

*[1]Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia, *branko.kordic@dh.uns.ac.rs*

[2]Department of Engineering and Natural Sciences, University of Applied Sciences Merseburg, Eberhard-Leibnitz-Strasse 2, 06217 Merseburg, Germany

The applicability of synthetic soils, composed of commercially available chemicals that simulate natural soil components, has been used as an effective tool for investigating soil composition through infrared spectroscopy. This study explores the potential of synthetic soil mixtures to simulate the complex infrared spectral characteristics of real soil. By systematically mixing selected pure components in varying ratios, synthetic soils representing diverse soil types were prepared and analyzed using infrared spectroscopy.

The infrared spectra of these synthetic mixtures were compared with those of real soils to assess their compositional similarity. Specific absorption bands corresponding to functional groups in minerals, organic matter, and other soil constituents were identified and analyzed. A spectral library of synthetic soil samples has been created to quickly estimate the closest match to a real soil sample. The results demonstrate a high degree of similarity between the synthetic soil spectra and the spectra of their natural counterparts, validating the effectiveness of this approach for the estimation of soil composition.

This method provides a controlled, reproducible framework for studying soil spectroscopy. The findings highlight the potential of synthetic soils as a simulation for real soil in spectroscopic investigations, offering a novel pathway for estimating soil composition efficiently. These insights pave the way for advancements in environmental science, agriculture, and related fields where soil characterization is essential.

Keywords: FTIR spectroscopy, Synthetic soil, Soil spectroscopy

Acknowledgement: This work was supported by the Provincial Secretariat for Science and Technological Development, Autonomous Province of Vojvodina, project no. 142–451-2198/2022–01.

BIOCHAR-BASED FERTILIZERS INCREASE CROP YIELDS IN ACIDIC SOILS OF ETHIOPIA

Betelhem Mekonnen*[1]*, Burkhard Wilske[1], Bezabih Addisu[2], Abebe Nigussie[2], Konrad Siegfried[1], Shimelis Gizachew[3], Tigist Yimer[3], Bishri Mohammed[3], Milkiyas Ahmed[2], Tilahun Abera[4], Amsalu Nebiyu[2], Reta Worku[4], Alemayehu Regassa[2], Tilahun Firomsa[4], Abdurahman Husien[4], Gebeyanesh Worku[2], Amante Lema[4], Amsalu Tilahun[2], Kefyalew Assefa[4], Bayu Dume[2], Getachew Eshete[1], Annett Pollex[1]

[1]DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Leipzig, Germany,
**betelhem.mekonnen.muluneh@dbfz.de*
[2]Jimma University − College of Agriculture and Veterinary Medicine (JUCAVM), Jimma, Oromia, Ethiopia
[3]Hawassa University, College of Agriculture, Hawassa, Sidama, Ethiopia
[4]IQQO – Batu Soil Research Centre (BSRC), Batu-Ziway, Oromia, Ethiopia

Depletion of soil organic carbon and nutrients creates mounting challenges for agricultural production in Ethiopia, putting livelihood and food security at risk. Biochar-based fertilizer (BBF) is suggested as the tool to maintain yields while concurrently improving soil organic carbon content and related soil functions. This study aims to evaluate the effects of different BBF formulations (biochar-digestate and biochar-vermicompost) on the yield of wheat and soil properties in the mid- and highlands of the Oromia and Sidama regions. Our results show that combining biochar with organic and/or inorganic fertilizers significantly increased above-ground biomass and dry grain yield in acidic soils. Application rates of 20 t/ha yielded the highest improvements, outperforming inorganic fertilizers by enhancing grain yields by up to 94% and biomass by 58%. Soil analyses revealed that BBF can increase soil pH, nutrient availability, and cation exchange capacity. Its effectiveness varied with soil conditions, showing limited impact in less acidic soils, which supports its specific role in mitigating soil acidity and related fertility deficiencies. Hence, BBF is a promising alternative for soil amendment for smallholder farms. Adoption of BBF into integrated soil fertility management will reduce the dependency on imported inorganic fertilizer and support circular bio-economy while contributing to carbon sequestration.

Keywords: Integrated soil fertility management, Agricultural residues, Biochar, Biochar-based fertilizer, Circular economy

Acknowledgements: The research was financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) within the initiative ONE WORLD – No hunger (grant number: 2021.0119.4).

VERTICAL BIOCHAR TRANSPORT IN SOIL IN A LONG-TERM FIELD EXPERIMENT IN GERMANY

***Ryan Pearson*[1]*, Arthur Gross[1], Tobias Bromm[1], Bruno Glaser[1]**

*[1]Martin Luther University Halle-Wittenberg, Institute of Agricultural and Nutritional Sciences, Soil Biogeochemistry, Von-Seckendorff-Platz 3, 06120 Halle (Saale), Germany, *ryan.pearson@student.uni-halle.de*

Biochar's long-term stability is valuable for its carbon sequestration potential in soil. The inert aromatic structure of biochar inhibits microbial decomposition and prolongs its mean residence time. In soil, biochar particles experience vertical transport, however, quantitative descriptions remain unclear due to insufficient long-term observations under field conditions. Decreasing topsoil biochar stocks were inspected in a long-term field experiment (covering 14 years) on a loamy soil in Germany. Four treatments were arranged in a Latin rectangle design: unamended control, pristine biochar, mixed with compost, and co-composted (31.5 Mg ha^{-1} biochar and 70.0 Mg ha^{-1} compost, respectively). Samples were retrieved in 30 cm intervals down to 90 cm. Benzene polycarboxylic acids were analyzed as a molecular marker for biochar. Results indicate vertical biochar translocation at fairly low rates between 0.04–0.28 Mg ha^{-1} transported to 30–60 cm and 0.03–0.23 Mg ha^{-1} transported to 60–90 cm, while 94–98% of the biochar remained in topsoil. Out of all treatments, pristine biochar exhibited the most transport. The contribution of higher condensed benzene polycarboxylic acids decreased vertically, indicating preferential transport of less condensed biochar compounds. This study proves biochar's vertical particle transport in soil, partially explaining decreasing topsoil stocks over time.

Keywords: Biochar aging, Carbon sequestration, Molecular marker, Organic soil amendment, Pyrogenic carbon

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INTERPRETABLE MACHINE LEARNING FOR SUSPENDED SEDIMENT PREDICTION IN A SEMI-ARID WATERSHED: A HYBRID MODELING APPROACH

***Houda Lamane*[1,2,3]*, Latifa Mouhir[1], Rachid Moussadek[2,3], Bouamar Baghdad[4], Ali El Bilali[5]**

[1]*Faculty of Sciences and Techniques of Mohammedia, Hassan II University of Casablanca, 28806 Mohammedia, Morocco, *lamanehoudageo@gmail.com*

[2]*National Institute for Agricultural Research (INRA), 10000 Rabat, Morocco*

[3]*International Centre for Agriculture Research in the Dry Areas (ICARDA), 10000 Rabat, Morocco*

[4]*Casablanca School of Architecture and Landscape, 20100 Casablanka, Morocco*

[5]*River Basin Agency of Bouregreg and Chaouia, 13000 Benslimane, Morocco*

Machine learning (ML) techniques have emerged as powerful tools for predicting suspended sediment concentration (SSC), though their limited interpretability poses challenges for understanding the underlying physical processes. This study presents a novel hybrid modeling framework that integrates four state-of-the-art ML algorithms: Extra Trees (ET), Random Forest (RF), Categorical Boosting (CatBoost), and Extreme Gradient Boosting (XGBoost), with Genetic Programming (GP) to enhance both predictive accuracy and interpretability.

The proposed models were applied to hydro-climatic data from the semi-arid Bouregreg watershed in northern Morocco, utilizing observations from 2016 to 2020 for model calibration and data from 2021 for validation. Model performance was assessed using three standard evaluation metrics: the correlation coefficient (r), root mean square error (RMSE), and Nash–Sutcliffe efficiency (NSE). To provide insight into model predictions, SHapley Additive exPlanations (SHAP) were employed for feature importance analysis.

All models demonstrated strong predictive performance, with NSE values ranging from 0.53 to 0.86, RMSE between 1.20 and 2.55 g/L, and r values between 0.83 and 0.91. Boxplot analyses further confirmed the enhanced performance of hybrid models over standalone algorithms. The best-performing configurations across four monitoring stations were: RF+GP at Aguibat Ziar, XGBoost+GP at Ain Loudah, CatBoost at Ras Fathia, and Random Forest at Sidi Med Cherif. The analysis of the models for different stations reveals that flow variables (including lagged flows) and seasonality are the most important predictors of SSC. Flow consistently emerges as the dominant factor influencing SSC, followed by seasonality, which often shows a negative association. The interpretability using SHAP values highlights how increases in flow generally lead to higher SSC, while seasonality tends to reduce it. Interactions between current and antecedent flow and rainfall also play a key role, reflecting the physical processes of sediment generation and transport within the watershed. These findings reveal that the models effectively capture the complex hydrological dynamics controlling sediment yield across the study area.

This framework proved effective and transparent for predicting SSC in semi-arid areas, addressing the 'black box' issue of ML models and providing valuable insights into the impact of SSC on water quality. Future research should explore SHAP and other explainable techniques, as well as incorporate additional input data to enhance prediction accuracy and better understand sediment transport processes.

Keywords: Sediment transport, Genetic Programming, SHAP values, Streamflow, Water quality modeling

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TOPIC 2.

Nutrient Management of Organic Soil Amendments

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Keynote lecture

MANURE MANAGEMENT AT FARM SCALE: PROBLEM OR OPPORTUNITY?

David Fangueiro[1]

[1]*Instituto Superior de Agronomia da Universidade de Lisboa, Portugal*

The main objective of this presentation is to provide information regarding the different steps of manure management at farm scale and highlight the value of manure as organic fertilizer and/or substrate for energy production.
The following topics will be considered:

1) Characteristics of manure
2) Animal manure management continuum
3) Main issues related to manure management, including gaseous emissions, water pollution and social aspects
4) Available solutions to minimize negative impacts associated with manure management.

Keywords: Manure, Organic fertilizer, Energy production, Soil

SLURRY ACIDIFICATION AS SOLUTION FOR SEVERAL PROBLEMS

David Fangueiro[1]

[1]*Instituto Superior de Agronomia da Universidade de Lisboa, Portugal*

The main objective of this talk is to introduce slurry acidification as a mitigation solution to minimize the environmental and societal impacts of manure management.
The following topics will be considered:

1) Acidification of manure: how does it work?
2) Available additives for manure acidification
3) Impact of acidification on gaseous emissions along the manure management chain
4) Impact of acidification on the agronomic value of slurry and nutrients leaching after soil application.

Keywords: Manure, Organic fertilizer,Aacidification,Soil

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Keynote lecture

GREENHOUSE GASES (GHG) EMISSION FROM DIFFERENT LAND USE

Zoran A. Galić[1]

[1]*Institute of Lowland Forestry and Environment, Novi Sad, Serbia*

In the past period, climate change was highlighted as a fundamental ecological problem and, so far, remains one. Greenhouse gases (GHG) emission was shown to have a predominant influence on global climate. In this context irreversible man-made changes, experienced by ecosystem, remain one of the predominant recent environmental problems. Land-use change (LUC), resulting in tremendous anthropogenic transformation GHG emissions is claimed by the Intergovernmental Panel on Climate Change (IPCC) to be among the main driving factors influencing climate change. Land conversion to urban and different types of agricultural ones is entailed by tremendous changes in soil cover and vegetation, emissions of energy and matter. Soils are part of the largest terrestrial ecosystem with a carbon pool. As the most important drivers of GHG emissions from soils, the soil temperature, soil water content, nutrients (C/N-ratios), soil pH value, land use, land cover, type and age of vegetation, local and regional climate, and hydrology were determined. Another gap in understanding of GHG emissions' variability and drivers behind it is non-uniform distribution of monitoring nets. At the microsite level, soil temperature and soil water content are the most dominant factors that affect CO_2 emissions from soils, where one of these drivers can be more influential than another.

Keywords: Climate change, Greenhouse gases, Soil

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PHOSPHORUS ADDITION IMPACTS ON SOIL NITROGEN DYNAMICS IN A SUBTROPICAL PLANTATION

Huijun Ye[1,2], Huiying Lin[1], Muhammed Mustapha Ibrahim[1], Leiru Chen[1], Yang Liu[1], Roland Bol[2]*, Enqing Hou[1]*

*[1]South China Botanical Garden, Chinese Academy of Sciences, 510650 Guangzhou, China, *houeq@scbg.ac.cn*

*[2]Forschungszentrum Jülich, IBG3, 52428 Jülich, Germany, *r.bol@fz-juelich.de*

Human activities have globally increased atmospheric nitrogen (N) deposition, which has exacerbated the risk of ecosystem N losses. Phosphorus (P), as a macroelement required for life, is closely linked to the biogeochemical cycle of N. Therefore, quantifying how the soil N cycle responds to different P supply levels is important. Here we examined the responses of soil N dynamics to altered P supply using a P addition experiment (+0, +25, +50, +100 kg P ha^{-1} yr^{-1}) in an evergreen broadleaf mixed plantation in subtropical China. We found that P addition led to a more open soil nitrogen cycle in the forest ecosystem. The primary source of N_2O emissions in the study plots was fungal denitrification, which accounted for 41%-52% of the total N_2O emissions, based on $\delta^{18}O$-N_2O, $\delta^{15}N\alpha$-N_2O, $\delta^{15}N^{bulk}$-N_2O and site preference measurements. Nitrogen loss by gas or water and N assimilation by plants were found to be coupled processes at the +25 kg P ha^{-1} yr^{-1} addition level. The $\delta^{15}N$-NO_3^- and $\delta^{18}O$-NO_3^- values in runoff and leaching water from different depths were all depleted from -10‰ to +0‰ in the wet season. This result indicates that soil N has a short residence time and rapid NO_3^--N loss in the forest ecosystem, and with fewer N conversions according to the isotope fractionation theory. These observed varied responses of soil N transformation, gaseous loss, and liquid loss to different P supply levels provide new insights into our understanding of N-P relationships in broadleaf forest plantations.

Keywords: Phosphorus addition, Nitrogen transformation, Nitrogen emissions, Nitrogen loss

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BIOCHAR AMENDMENT TO SOILS AS A TOOL TO PREVENT NUTRIENT LEACHING AND INCREASE N-USE EFFICIENCY IN LETTUCE PLANTS

***Alvaro F. García-Rodríguez*[1,2]*, Otávio dos Anjos Leal[2], Heike Knicker[1], Nina Siebers[2], Miguel A. Rosales[3], Roland Bol[2]**

*[1]Department of Food Biotechnology, Group of Interactions between Soils, Plants and Microorganisms, Instituto de la Grasa (IG-CSIC), UPO Campus, 41013 Seville, Spain, *alvaro.garcia.r@csic.es*

[2]Institute of Bio- and Geosciences, Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, Jülich 52428, Germany

[3]Department of Stress, Development and Signaling in Plants, Estación Experimental del Zaidín (EEZ-CSIC), 18008 Granada, Spain

Biochar's potential as a soil amendment has gained attention for enhancing nutrient use efficiency and mitigating environmental impacts, though its mechanisms of action, particularly in nitrogen (N) and phosphorus (P) cycling, remain unclear. This study evaluates biochar derived from *Miscanthus* in a coarse-textured agricultural soil as a means of enhancing N and P uptake by lettuce. In greenhouse conditions, lettuce (*Lactuca sativa* L.) was cultivated in pots and received ^{15}N-enriched NPK fertilizer at levels being limited, optimal, and excessive (0, 100, and 200 kg/ha). Biochar's impact on N cycling was assessed through stable isotope mass spectrometry, evaluating ^{15}N partitioning among plant biomass, soil, leachate, and microbial fractions. Leachate analysis quantified ^{15}N, P, and K retention during simulated heavy rainfall. Biochar degradation was monitored using isotopic ^{13}C signatures to distinguish biochar from native soil organic matter. Phosphorus dynamics was assessed by Olsen-P and sequential extraction, complemented by solid-state NMR spectroscopy. Plant physiological responses, including growth, chlorophyll content, and nutrient uptake, were related to substrate nutrient balance. Preliminary results suggest that biochar can improve N use efficiency and prevent nutrient leaching. This research supports sustainable agriculture by optimizing fertilizer practices, advancing nutrient cycling models, and enhancing understanding of biochar's role and fate during cultivation.

Keywords: Biochar, Fertilizer, Nitrogen, Phosphorus, Carbon signature

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EVALUATION OF AMENDMENT PROPERTIES, MINERALIZATION, AND EFFECTS IN SOIL AND CROPS

***Brian J. Young*[1]*, Pedro F. Rizzo[2,3]**

*[1]IDAEA-CSIC, Carrer de Jordi Girona 18-26, 08034 Barcelona, Spain, *brianjonathanyoung@gmail.com*

[2]BETA Center-University of Vic, Ctra. de Roda, 70, 08500 Vic, Spain, pedrofederico.rizzo@uvic.cat

[3]INTA, Av San Martín 3853, M5507 Mendoza, Argentina

The egg industry has increased its production worldwide during the last decades. Several strategies on waste management have been proposed to treat large volumes of poultry manure. Composting and anaerobic digestion are the main stabilization processes used. However, there are disagreements on the criteria for applying raw and treated poultry manure to the soil. We studied the relationship between physicochemical, toxicological, microbiological, parasitological, and metabarcoding parameters of raw and treated poultry manure (compost and digestate). Subsequently, we evaluated the mineralization of C, N and P, and the effects of amended soil on horticultural crops. Compost and digestate presented better general conditions than poultry manure to be used as an organic soil amendment. The highest pathogenic microorganisms content (total and fecal coliforms, *Escherichia coli*, and *Salmonella* spp.) was recorded in poultry manure. Multivariate analysis allowed associating lower phytotoxicity with compost and higher microbial diversity with digestate. Therefore, only compost presented stability and maturity conditions. We found high CO_2-C release, N loss, and P accumulation in soil amended with a high dose of poultry manure during mineralization. However, high doses of poultry manure and digestate increased the biomass production in the valorization assay. We recommend the soil application of stabilized and mature poultry manure-derived amendments, which reduce the negative impacts on the environment and promote more sustainable practices in agricultural systems.

Keywords: Poultry manure, Composting, Anaerobic digestion, Waste management, Phytotoxicity

Acknowledgements: This study was funded by the National Institute of Agricultural Technology (INTA; PNNAT 1128042) and the National University of Hurlingham (PIUNAHUR 5-04), Argentina. BJY thanks IDAEA-CSIC for the contract and PFR thanks BETA-UVIC for the postdoctoral fellowship.

THE EFFECT OF DIFFERENT MULCHING TYPES ON THE MYCORRHIZATION OF BLUEBERRY ROOTS AND THE GROWTH AND DEVELOPMENT OF BOTH ABOVEGROUND AND BELOWGROUND PARTS OF THE BLUEBERRY PLANT

***Emeliane Kiladze*[1]*, Nana Bitsadze[1]**

*[1]Laboratory of Mycology and Plant Pathology, Agricultural University of Georgia, Kakha Bendukidze Kampus, 0159 Tbilisi, Georgia, *ekila2021@agruni.edu.ge*

Blueberries (*Vaccinium corymbosum* L.), native to the United States, have seen increased global production and consumption. Ericoid mycorrhizal fungi enhance nutrient uptake in blueberries, improving yields, while mulching is a common practice to support plant growth.

This research aimed to evaluate the effects of organic and inorganic mulch types on the growth of blueberry plants and their root mycorrhization. A field experiment using the 'Legacy' variety, widely cultivated in Georgia, tested peat moss, pine needles, sawdust, and weed mat as mulches, arranged in a completely randomized design.

Results revealed that peat moss led to the highest root weights (wet: 68 g, dry: 22 g) and shoot growth (wet: 312 g, dry: 126 g, length: 81 cm). Slightly lower shoot weights were seen with a peat moss-weed mat mix. Other mulches, including the control treatment, showed lower growth, though differences were not statistically significant ($P > 0.05$). Root mycorrhization was highest in the control treatment (41%), with a significant difference ($P < 0.05$).

In conclusion, further research over a longer period and with different mulch types is needed to obtain more unambiguous results.

Keywords: Plant biomass, Mycorrhizal colonization, Vaccinium corymbosum, Organic and inorganic mulch

Acknowledgements: The research was supported by grants from the Shota Rustaveli National Science Foundation of Georgia (grant# PHDF-22-410), Agricultural University of Georgia, and LLC 'Blue Bash'.

IMPACT OF SUBSOIL MELIORATION AND LONG-TERM AGRICULTURE MANAGEMENT ON WATER USE OF ARABLE CROPS

***Leah Eitelberg*[1]*, Wulf Amelung[1], Elmarie Kotzé[2], Gert Ceroni[2], Chris du Preez[2], Kathlin Schweitzer[3], Michael Baumecker[3], Sara L. Bauke[1]**

*[1]INRES – Allgemeine Bodenkunde und Bodenökologie, Nussallee 13, 53115 Bonn, Germany, *eitelberg@uni-bonn.de*

[2]University of the Free State, 205 Nelson Mandela Drive, Bloemfontein, South Africa, kotzee@ufs.ac.za

[3]Albrecht Daniel Thaer-Institut für Agrar- und Gartenbauwissenschaften, Unter den Linden 6, 10099 Berlin, kathlin.schweitzer@agrar.hu-berlin.de

Climate change is assumed to intensify regional drought and water scarcity. As the largest global user of freshwater resources, agriculture is thus particularly susceptible to changes in the availability of freshwater supply and respective alterations of the soil moisture regime. Hence, sustainable agricultural management systems should be tailored towards efficiently using water resources within the soil, particularly in dry regions.

We conducted field experiments in dry arable regions in Germany and at Bloemfontein, South Africa, to test whether water storage in the soil and crop water use efficiency (WUE) can be enhanced by subsoil amelioration through deep loosening and incorporation of organic material. We analyzed stable oxygen isotope ($\delta^{18}O$) values of different soil depths to determine the water uptake depth. A dual approach model of carbon ($\delta^{13}C$) and oxygen isotopes in plant biomolecules was also applied to investigate the water use efficiency of maize (*Zea mays* L.). Additionally, $\delta^{18}O$ and $\delta^{13}C$ values were analyzed in different long-term field experiment sites in Germany to assess the impacts of irrigation and nitrogen (N) fertilization on the water uptake and WUE of arable crops.

The findings demonstrated that subsoil loosening combined with the incorporation of organic material promotes water uptake from deeper soil layers. However, the associated increase in biomass production intensifies water stress in the plants. This effect can be mitigated by compost applications, which enhance soil water retention. Moreover, higher levels of N fertilization appear to exacerbate water stress in crops, but this stress can be alleviated by supplemental irrigation and the incorporation of organic material into the soil where possible.

Our findings show that interactions between water and nutrient supply can exacerbate or alleviate water stress of arable crops, underscoring the need for an integrated approach to ensure efficient use of water resources in agricultural soils.

Keywords: Subsoil melioration, Organic amendments, Stable carbon isotopes, Stable oxygen isotope, Water-use efficiency

Acknowledgements: The study received funding from the German Federal Ministry of Education and Research (BMBF) in the framework of the funding measure 'Soil as a Sustainable Resource for the Bioeconomy - BonaRes', project BonaRes (Module A): BonaRes Center for Soil Research, subproject 'Sustainable Subsoil Management – Soil3' (grant no. 031B1066A to YS) and from the Studienstiftung des deutschen Volkes (to LE), which is greatly acknowledged.

HOW MONOSACCHARIDE IMPREGNATION OF FEEDSTOCK AFFECTS NUTRIENT RELEASE FROM OBTAINED BIOCHAR?

***Karol Osipiuk*[1]*, Patryk Oleszczuk[1]**

*[1]Department of Radiochemistry and Environmental Chemistry, Faculty of Chemistry, 3 Maria Curie-Skłodowska Square, 20-031 Lublin, Poland, *karol.osipiuk@gmail.umcs.pl*

Excessive or overly intensive use of fertilizers leads to environmental degradation and reduced crop efficiency. These practices result in the loss of nutrients that plants do not absorb and subsequently leach into surface and groundwater, contributing to eutrophication. Given the depletion of raw materials for fertilizer production, high production costs, and the negative impacts of overapplication, it is essential to explore new solutions. One promising material is biochar with slow nutrient release properties, which, due to its long carbon residence time in soil, requires only a single application, unlike synthetic fertilizers. The aim of the study was to evaluate the capacity of biochars, produced from wood sawdust impregnated with glucose (GLU) and fructose (FRU) solutions at various concentrations, to gradually release nutrients such as potassium (K), phosphorus (P), and magnesium (Mg). The biochars were labeled according to the type of impregnating material, its concentration, and the pyrolysis temperature, e.g., BC550, 10GLU550, 10FRU750, etc. Our research compared biochars from unmodified sawdust to those from modified sawdust, all produced at two pyrolysis temperatures (550ºC and 750ºC).

The use of glucose or fructose solutions resulted in biochars exhibiting the property of slow release of potassium, phosphorus, and magnesium. The best materials for slow potassium release were biochars obtained by impregnation with the highest concentrations of simple sugars: 50GLU550, 50FRU550, 50GLU750, and 50FRU750, which after 96 hours released 17.4, 28.3, 18.9, and 18.3 times less potassium than the control, respectively. For magnesium, it was concluded that among the biochars at 550ºC, 10GLU550 and 50FRU550 had the best capacity for slow Mg release (28.0 and 25.4 times less magnesium than the control, respectively). In contrast, the best materials at the higher temperature were 30FRU750 and 50FRU750 (56.6 and 27.0 times less magnesium than the control, respectively). In the case of phosphorus release, the materials called 10GLU550 and 30FRU750 were identified as the best for use as slow-release P materials (release 15.5 and 4.6 times less phosphorus than the control, respectively). These results emphasize the rationale for using simple sugars as readily available and biodegradable materials for impregnating feedstock to produce biochars with slow nutrient release properties.

Keywords: Slow release of nutrients, Carbon materials, Fertilizers

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CROP RESIDUE AS AN ORGANIC AMENDMENT: MODELLING BENEFITS AND TRADE-OFFS

Jayantifull Hoojon[1], Idhayachandhiran Ilampooranan[1]*

*[1]Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, Roorkee 247667, India, *idhaya@wr.iitr.ac.in*

Crop residue, if returned, protects the soil from being eroded, retains organic matter, and serves as a source of nutrients and energy for soil microbes. In this study, the DeNitrification DeComposition (DNDC) model was used to simulate the impact of varying percentages (0, 25, and 50%) of Crop Residue Return (CRR) on rice yield, soil organic carbon (SOC), soil organic nitrogen (SON), methane (CH_4), and nitrous oxide (N_2O) emissions. The simulation was carried out for 30 years (2011-2040) at an experimental field in Punjab Agricultural University, India. Results showed that rice yield was unaffected by CRR because the field was fertilized; hence, nutrient dependency on residue was lower. SOC and SON levels increased in all scenarios, where SOC increased by 31.3, 133.3, and 241.1 kg $ha^{-1}yr^{-1}$, and SON increased by 31.3, 133.3, and 241.1 kg $ha^{-1}yr^{-1}$ in 0, 25, and 50% CRR, respectively. CH_4 emission was elevated at higher levels of CRR due to the availability of more organic substrates for methanogenesis. Conversely, N_2O emission remained unaffected, likely due to the high C:N ratio of rice residue, which slows down the release of N and its availability for denitrification, a key process for N_2O emissions. The study underscores the positive impact of CRR on soil organic matter and highlights the trade-off with high CH_4 emissions under high CRR.

Keywords: Crop residue return, DNDC, Soil organic carbon, Soil organic nitrogen, Emissions

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TOPIC 3.

Carbonising Sewage Sludge or Biosolids to Remove Pollutants

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Keynote lecture

CRUCIAL ASPECTS OF PHOSPHORUS RECOVERY FROM SEWAGE SLUDGE IN CONTEXT OF CLIMATE CHANGE

Helmut Gerber[1]

[1]*PYREG GmbH – CTO; European Biochar Industry Consortium (EBI) – Member of the Board*

Recent accelerated climate change and rising temperatures are excelling existing environmental problems in the Mediterranean Basin that are caused by the combination of changes in land use, increasing pollution and declining biodiversity. In most impact domains (such as water, ecosystems, food, health and security), current changes and future scenarios consistently point to significant and increasing risks during the coming decades. In the Mediterranean region, average annual temperatures are now approximately 1.5°C higher than during the period 1880-2019 (Fig.1), well above current global warming trends [1].

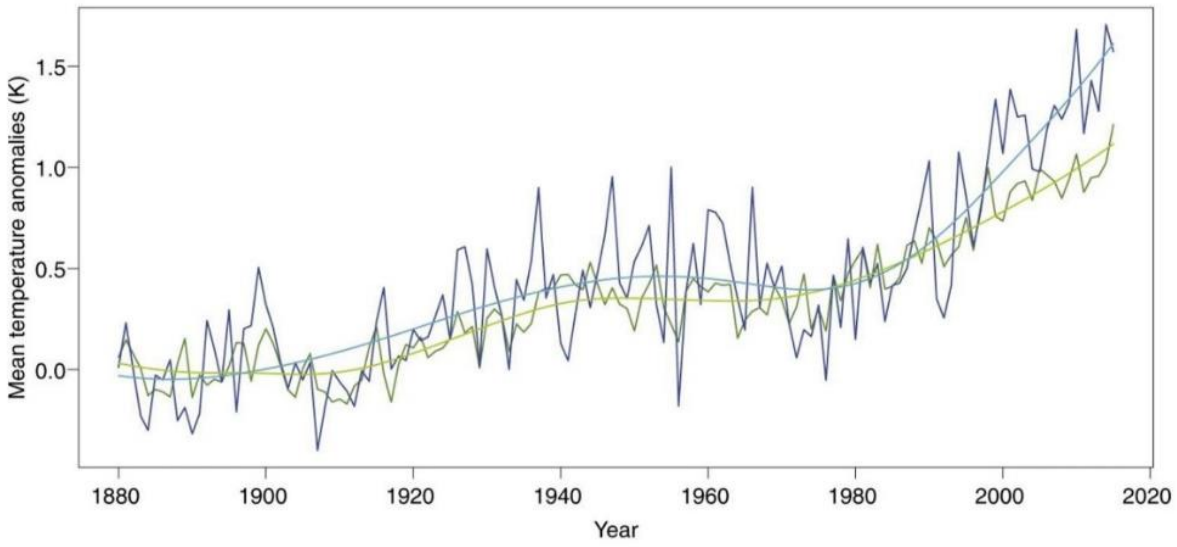

Fig. 1. Average annual temperatures during the period 1880-2019

Warming of the atmosphere (annual mean temperature anomalies with respect to the period 1880-2019), in the Mediterranean Basin (blue lines, with and without smoothing) and for the globe (green line). Policies for the sustainable development of Mediterranean countries need to mitigate these risks. Studies suggest that 30% of semiarid Mediterranean drylands (Fig. 2) are affected by desertification and that 47% of the region's people suffer these effects [2].

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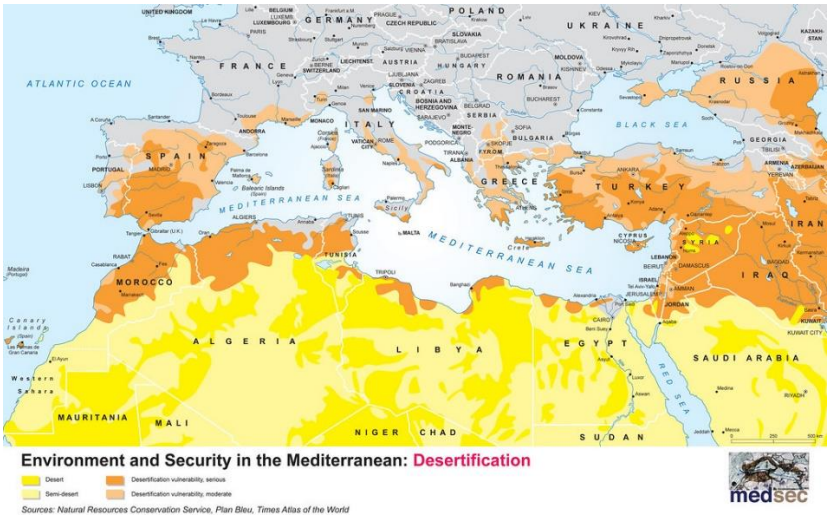

Fig. 2. Environment and Security in the Mediterranean: Desertification

Soil degradation affects more than one billion people worldwide, particularly in dry regions, where around 40% of the world population live. Soil degradation is indicated mainly by a loss of soil functions, a large portion of which depends on soil aggregation and soil organic matter (SOM) storage within aggregates. The provision of microbial substrate by compost and of habitat by biochar are central in sustainable soil amelioration. A new field of biochar and compost application is the large-scale rehabilitation of degraded soils to restore their functions and to enable sustainable use over the long term [3]. Biochar addition in soils increases besides other eligible effects water use efficiency and plant available soil water [4].

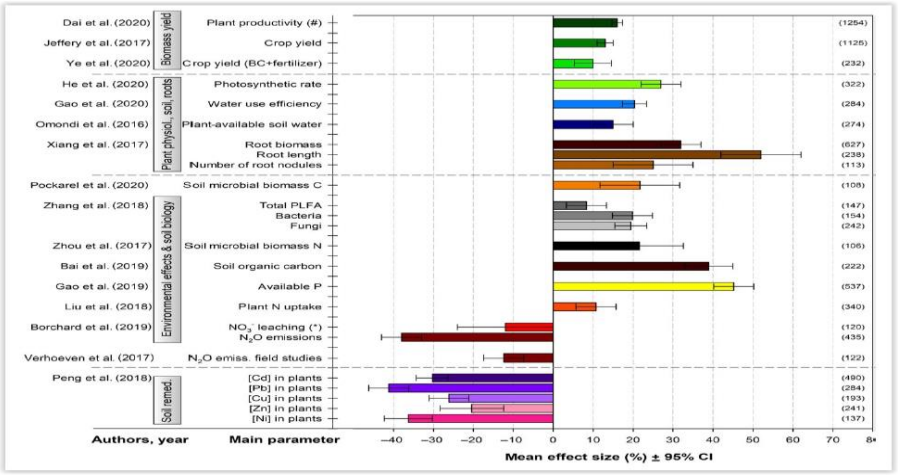

Fig. 3. Main parameters of soil and effect sizes presented in the literature

Emissions reduction alone is no longer sufficient to contain the climate crisis. In parallel with the reduction of emissions, a start must now be made on expanding and further developing the existing options for creating carbon sinks (Fig.4). The magnitude of the task is enormous: In order to achieve climate neutrality in the European Union, the volume of sinks to be created annually must increase to at least 850 million tonnes of CO_2 by the year 2050 [5].

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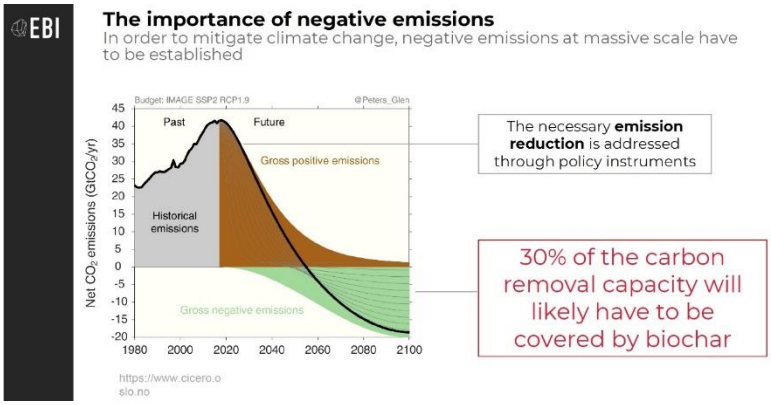

Fig.4. Negative emission as a key factor for mitigation of climate changes

Biomass pyrolysis and agricultural use of the biochar is thus a key technology for saving the climate. Biochar has been intensively researched in recent years. A wealth of experience with its applications and innumerable scientific publications prove today that in addition to its direct climate benefit as a carbon sink, biochar can be used in agriculture in many profitable and beneficial ways. Besides the carbon sink effect, sewage sludge biochar delivers a highly valuable phosphorus source with a high P recovery rate [6].

Global warming potential (GWP) of different fertilizers

The 2019 study by the German Federal Environmental Agency [6] showed that conventional fertilizer production in Germany emits about +1.2 kg CO_2 eq /kg P_2O_5. Furthermore, phosphate recovery processes like precipitation (in digested sludge or centrate) or sewage sludge ash also demonstrably cause CO_2 emissions. Using the same calculation methodology in comparison to the global warming potential (GWP) of these processes, PYREG biochar from sewage sludge has a negative GWP of -4,01 kg CO_2 eq /kg P_2O_5 (Fig. 5). Consequently, the recovery of phosphate within the PYREG process and the final application of the biochar contributes to fight global warming, increase water use efficiency and reaching net zero.

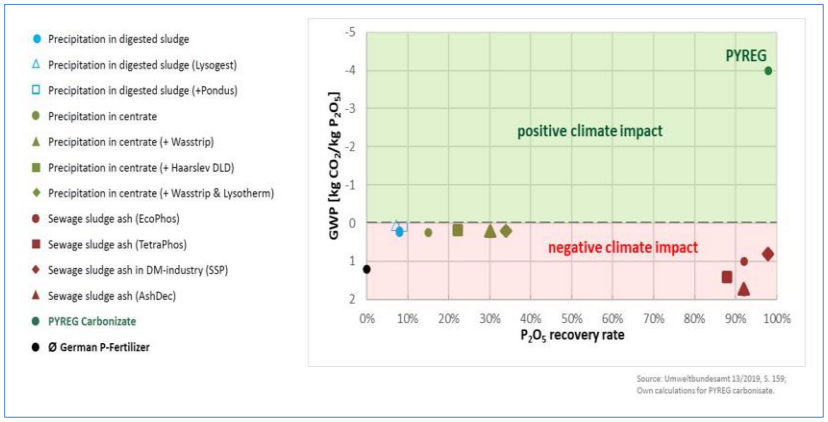

Fig. 5. GWP of PYREG biochar

Keywords: Biochar, PYREG, Phosphorus recovery

References:

[1] Cramer W et al. (2018) Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 8, 972-980
[2] RISKS ASSOCIATED TO CLIMATE AND ENVIRONMENTAL CHANGES IN THE MEDITERRANEAN REGION A preliminary assessment by the MedECC Network Science-policy interface - Report on the State of the Environment and Development in the Mediterranean (SoED 2019)
[3] Zirted, Michaël, Toumba, Daniel, Danmori, Idrissou, Bruno Olivier, Rouama, Paggo, Rouama, Gove, Arafat, Jourmbi, Zirted. (2023). Assessment of the efficiency of ReviTec technology for soil restoration in sudano-sahelian part of northern Cameroun: Case of Hardé soils of Maroua-Salak. 59 No. 331. 1-10.
[4] Biochar in agriculture – A systematic review of 26 global meta-analyses Hans-Peter Schmidt; Kammann, Claudia; Hagemann, Nikolas; Leifeld, Jens; Bucheli, Thomas D; Sánchez Monedero, Miguel Angel; Maria Luz Cayuela. Global Change Biology. Bioenergy; Oxford Bd. 13, Ausg. 11, (Nov 2021): 1708-1730. DOI:10.1111/gcbb.12889
[5] Harald Bier, Helmut Gerber, Marcel Huber, Hannes Junginger, Daniel Kray, Jörg Lange, Hansjörg Lerchenmüller, Pål Jahre Nilsen: 2020 EBI Whitepaper Biochar based carbon sinks to mitigate climate change. European Biochar Industry Consortium e.V. (EBI), online.
[6] Gerber, Helmut 2023: ESPP workshop at the EBI Biochar Summit Helsingborg, 12.-15.06.2023, Conference proceedings online
[7] UBA TEXTE 13/2019: Ökobilanzieller Vergleich der P-Rückgewinnung aus dem Abwasserstrom mit der Düngemittelproduktion aus Rohphosphaten unter Einbeziehung von Umweltfolgeschäden und deren Vermeidung, Forschungskennzahl 3716 31 330 0 UBA-FB 002759, ISSN 1862-4804.

Keywords: Biochar, PYREG, phosphorus recovery

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Keynote lecture

EFFECT OF THE CARBONIZATION PROCESS OF SEWAGE SLUDGE ON THE PROPERTIES OF THE CHARS AND THEIR POTENTIAL BENEFITS AS SOIL AMENDMENTS

Marina Paneque [1]

[1]*Agricultural Faculty of Seville University, Spain*

Containing high amounts of nitrogen (N), phosphorus (P) and organic matter (OM), sewage sludge (SS) constitutes an excellent feedstock to produce soil amendments. Applied to contaminated sites, SS can improve soil health by increasing soil OM and by providing nutrients both to plants and soil microbiota. However, adding untreated SS directly to the soil can create hygienic problems. Its low biochemical stability can lead to N and P leaching, meaning that instead of being recycled for the production of plant biomass, these nutrients turn into potential contaminants of groundwater. The thermochemical carbonization of SS at elevated temperatures in the absence or low presence of oxygen has been considered to achieve the needed stabilization and hygienization of this material. In addition, compared to other treatments like composting, during carbonization all organic pollutants usually found in this residue are destroyed. In the presence of water, this low-oxygen carbonization is called hydrothermal carbonization (HTC), whereas in the absence of water it is known as pyrolysis. The solid by-product that results from pyrolysis can be called pyrochar, whereas the product of HTC is usually called hydrochar.
Both types of carbonizations include reactions such as dehydratation, decarboxylation, aromatization and recondensation. However, our studies showed that the different process conditions lead to significant differences of both the chemistry and physical characteristics of the solid products, therefore varying their potential benefits once applied to soils. Detailed characterization of the pyrolysis products showed that SS-hydrochars preserved a higher amount of N than SS-pyrochars, whereas pyrolysis led to a higher relative enrichment of P than HTC. During carbonization, part of the N is incorporated into heterocyclic aromatic structures. Pot experiments confirmed that these forms are biochemically more recalcitrant than the original peptide-like N in SS, confirming that SS-hydrochars can act as a slow-release source of N for soils. In contrast, SS-pyrochars, due to its lower N content and higher condensation degree compared to hydrochars, seemed to be more suited to increase soil OM in the long-term at the same time that P is provided. Subsequent pot experiments monitoring the biochemical degradability of SS-chars and their impact on soil N and P cycles confirmed this hypothesis.

Keywords: Carbonization, Sewage sludge, Soil amendments

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HYDROTHERMAL CARBONIZATION AS A SUSTAINABLE SOLUTION: LINKING WASTE MANAGEMENT (SDG 12), CLEAN WATER (SDG 6), AND CLIMATE ACTION (SDG 13)

***Nataša Đurišić Mladenović*[1]*, Snežana Maletić[2]**

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia,*
**natasadjm@tf.uns.ac.rs*

[2]*University of Novi Sad, Faculty of Science, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, Novi Sad, Serbia*

The thermochemical conversion of sewage sludge presents significant challenges due to its high moisture content, which makes pyrolysis and gasification inefficient and energy-intensive processes. Hydrothermal Carbonization (HTC) may be considered as a promising alternative, capable of converting wet biowaste into a valuable carbon-rich product – hydrochar – under moderate temperatures and self-generated pressure, without the need for extensive drying if compared to the conventional ("dry") pyrolysis. Hydrochar has diverse potential applications, serving as a soil amendment, energy source, adsorbent, or catalyst carrier. By producing hydrochar, HTC not only facilitates waste valorization but also advances circular economy principles by transforming waste streams into valuable resources. Thus, this HTC of sewage sludge aligns with several key Sustainable Development Goals (SDGs), mainly addressing Clean Water and Sanitation (SDG 6), Responsible Consumption and Production (SDG 12), and Climate Action (SDG 13). This presentation will explore the role of HTC in sewage sludge management, with a particular focus on the application of the resulting hydrochar to enhance wastewater treatment efficiency, specifically in the removal of emerging organic contaminants.

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NANO-BIOCHAR FOR SUSTAINABLE REMEDIATION OF POTENTIALLY TOXIC ELEMENTS-CONTAMINATED SOILS: A FOCUS ON FOOD SAFETY AND CIRCULAR ECONOMY

Monika Raczkiewicz[1], Patryk Oleszczuk[1]*

[1]Department of Radiochemistry and Environmental Chemistry, Faculty of Chemistry, 3 Maria Curie-Skłodowska Square, 20-031 Lublin, Poland

The increasing contamination of soils with potentially toxic elements (PTEs), such as cadmium (Cd), lead (Pb), and chromium (Cr) poses significant risks to environment agricultural productivity, human health and sustainability. Conventional remediation methods, including soil washing and phytoremediation, often face limitations such as high costs, secondary pollution, and low long-term efficacy. Biochars, produced through the pyrolysis of organic waste, have emerged as promising tools for PTEs immobilization due to their porous structure, high cation exchange capacity, and ability to improve soil properties. However, modification of biochars particles to nanosize (nano-biochars) offers enhanced properties, including greater surface reactivity and adsorption capacities, presenting new opportunities for effective and sustainable soil remediation. The aim of this study was to evaluate the remediation potential of palm bunch (PB), rice husk (RH) and sewage sludge (SSL)-derived nano-biochars (n-BC) in PTEs-contaminated soil, focusing on n-BCs impact on soil properties, PTEs bioavailability, and the growth and quality of *Lactuca sativa L*. Our study specifically focused on waste-derived biochars, which not only valorize waste but also align with circular economy principles, contributing to sustainable waste management practices. In our research, we compared n-BC with bulk biochar (b-BC) to evaluate effectiveness of size reduction on remediation potential. A six-week pot experiment demonstrated that n-BC amendments significantly reduced the bioavailable (extracted with H_2O and $CaCl_2$) fractions of Cr, Cu, Fe, Mn, Ni, Zn, and Pb in soil, with higher immobilization efficiencies by 4.2% to even 305% than corresponding bulk counterparts (b-BC). According to NICA-Donnan modelling, the main PTEs immobilization mechanisms were precipitation and ion exchange. Application of n-BC also resulted in a notable decrease in PTEs concentrations in lettuce leaves (ranging from 29.7% to 100%), thereby reducing both the bioaccumulation factor and health risk index. Among the different BCs, SSL-derived n-BC demonstrated the highest immobilization capacity and the most substantial reduction in PTEs uptake by plants. These findings highlight the potential of n-BC as a highly effective and low-cost amendment for rapid mitigation PTEs contamination in agricultural soils, enhancing food safety, and supporting circular economy principles by utilizing organic waste materials.

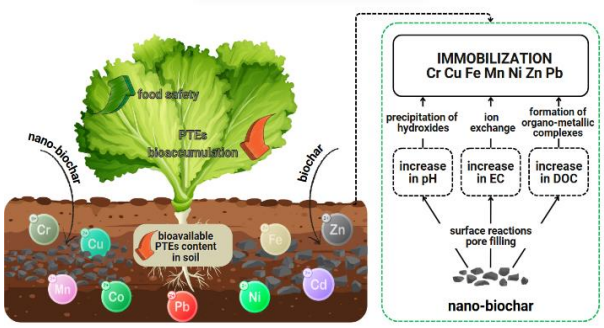

Figure 1. General mechanisms of PTE fate in the b-BC/n-BC soil system.

Keywords: Trace metals, Leachates, Carbon materials, Plants, Particle size

Acknowledgements: The project was funded by the National Science Centre granted on the basis of the decision number DEC- 2021/42/A/ST10/00161..

DEWATERING AND TREATMENT OF DOMESTIC SEWAGE SLUDGE USING CONSTRUCTED REED BED

***Tahra Al-Rashdi*[1]*, Mushtaque Ahmed[2], Alexandros Stefanakis[3]**

*[1]College of Applied Sciences and Pharmacy, University of Technology and Applied Sciences (UTAS), Muscat, PO Box 74, Alkhuwair, Sultanate of Oman, *tahra.alrashdi@utas.edu.om*

[2]Dept. of Soils, Water & Agricultural Engineering, College of Agricultural & Marine Sciences, Sultan Qaboos University. PO Box 34 Al-Khod 123, Sultanate of Oman

[3]Laboratory of Environmental Engineering and Management, School of Chemical and Environmental Engineering, Technical University of Crete, Chania 73100, Greece

The Sultanate of Oman produces a high volume of wastewater on a daily basis. Since conventional/mechanical wastewater treatment methods are mostly used in the country, a relatively high volume of sludge by-product is also generated daily. Sludge is defined as a mixture of water, organic matter, and inorganic matter resulting from the biological treatment of wastewater. Oman manages the generation of sludge by discharging about 84% of it in the landfills, especially the Sewage Treatment Plants (STPs) located outside the capital city of the country (Muscat Governorate), while about 16% of produced sludge is collected by Oman Water and Wastewater Services company and is further processed through composting to produce a fertilizer ('Kala' brand name). This compost production covers a small amount of the sludge volume, while the associated high costs make it prohibitive to upscale this practice to all STPs across the country. In addition, many small STPs in the country simply dump the generated sludge into the environment after simply sand drying process.

For these reasons, revolutionary and cost-effective means and ways are needed to manage the sludge for environmentally friendly sound disposal and reuse. One of the promising and state-of-the-art sustainable technologies is the constructed wetland technology for dewatering and stabilization of sludge. The Sludge Treatment Wetland (STW) system depends on the type of substrate, type of plants and microbial communities that play an important role in the treatment and dewatering of the sludge. In addition, it contributes to the decentralized management of sludge, a parameter that is crucial for small and medium STPs.

This study focuses on the construction of STWs, i.e., vertical flow constructed wetland designed for sludge dewatering, using local common reed plants (Phragmites Australis) to treat activated sludge from Alseeb STP. A pilot-scale experiment was conducted in an agricultural experiment station. This study is the first one in Oman and across the Arabic peninsula that tests the STW technology. The study consisted of 18 mesocosms tanks. Each tank has dimensions of 89 cm in height and 0.5 m^2 surface area. The freeboard in each tank was 54 cm above the top gravel layer. The units are filled with substrate media from top to bottom: 15 cm fine gravel (2-6 mm), 15 cm medium gravel (15-25 mm) 5 cm and drainage layer of cobbles (40-60 mm). Two plastic tubes extending vertically with an open top are embedded in the bottom of each unit. The various units have different construction and operation parameters such as planted and unplanted beds (i.e., presence and absence of plants) and three different sludge loading rates (SLR; 75, 100, 125 kg/m^2/year).

The results showed the dewatering efficiency reached 97% for the planted STWs compared to 91% for the unplanted beds. The total solids content in the dewatered sludge for the three SLRs (75, 100 and 125 m^2/kg/year) were between 23 -56%, 16-57% and 11-42%, respectively. These first results demonstrate that a high total solid content in the dewatered sludge can be achieved

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even at a relatively high SLR of 100 m^2/kg/year after 2 years of operation. This means that the dry content can be further increased in the final resting phase that is going to be applied before the emptying of the biosolids from the units.

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THE INFLUENCE OF PYROLYSIS TEMPERATURE ON THE PROPERTIES OF BIOCHAR DERIVED FROM WHEAT STRAW

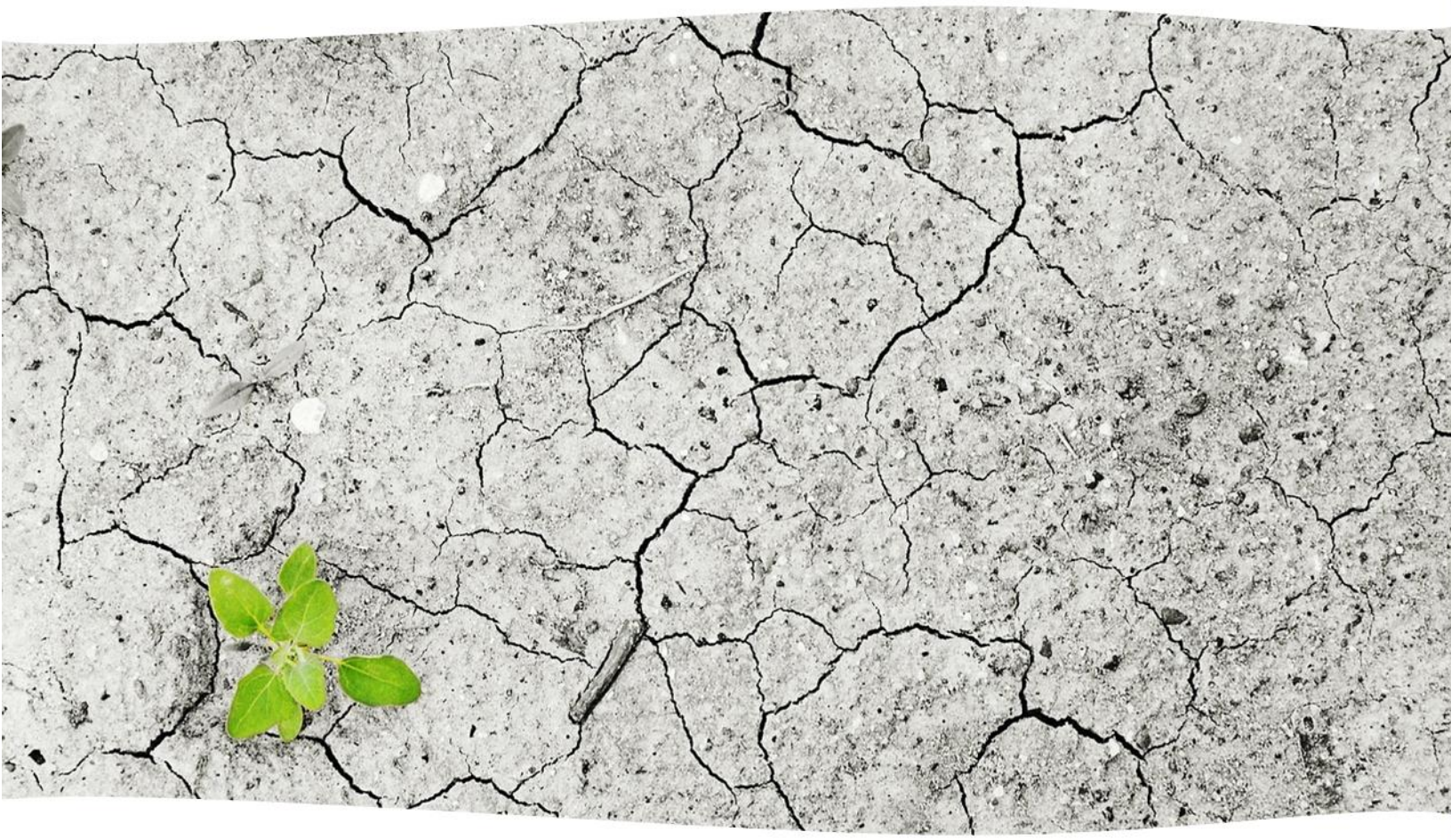
Nina Đukanović*[1]*, Tamara Apostolović[1], Jasmina Anojčić[1], Sanja Mutić[1], Tijana Marjanović Srebro[1], Snežana Maletić[1], Jelena Beljin[1]

*[1]Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia, *nina.djukanovic@dh.uns.ac.rs*

Biochar, as a carbon-rich material, can be obtained from various organic feedstocks using slow pyrolysis, a thermal decomposition process that occurs in the absence of oxygen. The type of biomass, temperature, and retention time significantly affect the physicochemical and structural properties of biochar. Due to its diverse properties, biochar is a material with potential for environmental applications. This work aimed to examine the effect of pyrolysis temperature on the properties of biochars obtained by pyrolysis of wheat straw at temperatures of 400°C and 700°C for 1 h in an inert atmosphere. The biochars are labeled as WS400 and WS700. For the characterization of the biochars, Brunauer-Emmett-Teller method (BET), X-ray diffraction (XRD), Raman spectroscopy, thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS) were performed. SEM images show that WS700 has significantly more cracks and deep, wide pores of small size, with almost completely degraded fibers compared to WS400. SEM results were confirmed by the specific surface area (SSA) obtained by BET analysis, as SSA increased from 3.68 m^2g^{-1} for WS400 to 80.88 m^2g^{-1} for WS700. The elemental composition of the produced biochars, determined by EDS in combination with CHNS analysis, shows that in both biochars the carbon content was significantly high compared to the other elements (about 66%), while the second major element was oxygen (6.5-8.5%), and all other elements in the biochars contained mostly less than 1%. The total weight loss during TGA was about 89% for WS400 and about 82% for WS700, with the highest thermal degradation observed between 300 and 500 °C. XRD analysis resulted in similar diffraction patterns for both biochars. One broad peak was observed in the band with a peak at around 2θ=23°, indicating the presence of graphitic carbon planes (002). Two sharp peaks were observed for both biochars at around 2θ=29°, indicating the presence of mineral components, such as calcium carbonate, and at around 2θ=40°, corresponding to the (220) crystal plane in the cubic structure of KCl. Raman spectroscopy for these two biochars was not specific, as the D band was not pronounced, so the I_D/I_G ratio could not be calculated, and for WS700 there was a flat line along the entire spectrum. For WS400 biochar, a peak at approximately 1592 cm^{-1} was identified as the G-band, which corresponds to in-plane vibrations of sp^2-bonded carbon atoms in the graphitic structures and can be attributed to aromatic ring systems in the biochar. The results indicate that increasing the pyrolysis temperature from 400°C to 700°C significantly enhances the porosity and specific surface area of wheat straw-derived biochar, making it more suitable for environmental applications. Structural and compositional analyses confirm that higher temperatures promote carbonization and mineral retention, which can influence biochar's adsorption properties and stability.

Keywords: Biochar, Wheat straw, Slow pyrolysis, Characterization

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential–EnviroChar.



TOPIC 4.

Fate and Transport of Emerging Pollutants from Organic Soil Amendments in Agricultural Soils

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Keynote lecture

POTENTIAL AND LIMITATIONS OF SORBENT AMENDMENTS FOR INCREASED MICROPOLLUTANT REMOVAL IN THE SOIL PASSAGE

Gabriel Sigmund [1]

[1]*Wageningen University & Research, Netherland*

As the global demand for safe and clean water continues to rise, we face challenges associated with the depletion of freshwater resources due to overexploitation, contamination, insufficient wastewater treatment, and the climate crisis. Safeguarding and improving water quality is of seminal importance for societies and ecosystems worldwide. One technology to safeguard and increase clean water resources is the soil passage. Soil passage based technologies are dune infiltration (DI), managed aquifer recharge (MAR), and riverbank filtration (RBF). In all of these approaches, water is passed through natural soil or sediment layers for purification purposes. To increase pollutant removal in these natural systems, sorbent materials including carbon based sorbents and Iron oxides could increase sorptive removal and increase retention for potentially increased microbial degradation. This talk will explore the potential and limitations of such approaches to remove chemical pollutants from water. Therein, concepts of preferential sorption and strategies to increase degradation will be critically discussed, considering environmental factors and the range of chemical structures of organic micropollutants influencing these processes.

Keywords: micropollutant, climate, soil passage

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Keynote lecture

EMERGING CONTAMINANTS IN ORGANIC SOIL AMENDMENTS

Thomas D. Bucheli[1]

[1]*Environmental Analytics, Agroscope, Reckenholzstrasse 191, CH-8046 Zürich, Switzerland*

Organic fertilizers or soil improvers comprise biogenic wastes of different kind and origin, e.g. agricultural and municipal green waste, food waste, animal manure, and sewage sludge, and are amended to soil either in their original or processed form (e.g. composted, digested or pyrolyzed). Such materials can be contaminated with a plethora of (organic) contaminants. They can originate from the feedstock material itself (e.g., phyto- or mycotoxins, steroid hormones), are residues of everyday chemicals used in private households, industry or agriculture (e.g., (veterinary) pharmaceuticals, personal care products, pesticides, (micro-)plastics), or unintended products of biowaste processing (e.g., dioxins, polycyclic aromatic hydrocarbons). Application of organic fertilizers and improvers to soil inevitably leads to inputs of these contaminants into terrestrial ecosystems, where they are subject to subsequent environmental fate and transport processes. The width and breadth of the topic is illustrated with a recent compilation of contaminants regulated and monitored in external organic matter and some case studies conducted in the research group of the presenter.

Keywords: Organic fertilizers, soil quality, soil amendments

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

***Prudence W. Mhlophe*[1]*, Jaime L. Toney[1], Adrian M. Bass[1], John W. Crawford[1]**

*[1]University of Glasgow, University Avenue, Glasgow G12 8QQ, Scotland, UK, *p.mhlophe.1@research.gla.ac.uk*

Heavy metal contamination is one of the biggest threats to both urban and agricultural soils. While past remediation approaches were prioritised for efficacy, new methods are being evaluated for sustainability, affordability, and multifunctionality. The use of waste coffee grounds for soil remediation is an excellent example of a sustainable remediation technology due to the abundance and low cost of biomass and its involvement in waste reuse. This research explores whether additional modifications can improve the efficacy, particularly for multi-metal contaminated soils. This study aimed 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 were 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% by mass; 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, TN, and ICP-OES. On day 29, Pak choi seeds were planted in the columns and left to grow for 63 days. Results analysis is underway. 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. There is an indication that the treatments have significant effects on the soil properties, so there is an expectation that this will affect heavy metal concentrations in the soils.

Keywords: Soil contamination, Spent coffee, Biochar, Heavy metals, Remediation, Circular economy

Acknowledgements: A huge appreciation for James McCune Smith and GALLANT for funding this project.

ORGANOCHLORINE PESTICIDES AND POLYCHLORINATED BIPHENYLS IN SOILS SURROUNDING A HEXACHLOROCYCLOHEXANE DUMP SITE

***Marinela M.C. Cvetanoska*[1]*, Ivona I.S. Sofronievska[1], Pece P.S. Sherovski[1], Milena M.S.K. Spasovska Kolevska[1], Jane J.B. Bogdanov[1], Jasmina J.P.S. Petreska Stanoeva[1], Marina M.S. Stefova[1]**

*[1]Institute of Chemistry, Faculty of Natural Sciences and Mathematics, University "Ss. Cyril and Methodius" in Skopje, Arhimedova 5, 1000 Skopje, R. N. Macedonia, *marinela.cvetanoska@pmf.ukim.mk*

In the heart of Skopje, the capital of Macedonia, lie the remnants of the former chemical plant OHIS. Within the plant's grounds are two landfills containing lindane isomers (α-, β- and δ-hexachlorocyclohexane) and other organic compounds that have been left untreated for years. Over time, rainwater has caused these substances to seep deep into the soil, contaminating the surrounding areas. These landfills are a source of hexachlorocyclohexane (HCH) isomers, as well as small amounts of polychlorinated biphenyls (PCBs). Cleanup and decontamination efforts at this site began in 2021, and our laboratory initiated an independent monitoring process to prevent further environmental pollution.

This study aimed to implement a monitoring scheme to assess HCH and PCB residues in the soil surrounding the former HCH dump site. Monthly surface soil samples were collected from two sites (L1 and L2) near the former chemical plant. The results presented here cover the period from April to November 2024. Soil samples were composited from five subsites within a 2 x 2 m square plot at a 30 cm depth.

A total of 13 organochlorine pesticides (OCPs) and 9 PCBs were detected. Total OCP content in samples from L1 was in the range 0.77–79.50 μg/kg, where highest concentrations were measured for α-HCH and δ-HCH (37.23 and 20.79 μg/kg, respectively). Highest concentration of total PCBs was measured in Juky 2024 (121.85 μg/kg) with PCB-153 and PCB-180 (34.73 and 39.34 μg/kg, respectively) being the most abundant. Highest content of OCPs in the second sample (L2) was measured in November (45.61 μg/kg), while highest content of PCBs was measured in May (141.62 μg/kg). Only β-HCH was detected continuously during the monitoring period, it being the most abundant OCP (0.20–34.99 μg/kg). This is explained by the close proximity of this location to the chemical plant. Among the most abundant PCBs at this location were PCB-101 and PCB-138 (48.69 and 39.40 μg/kg, respectively).

In conclusion, content of PCBs and OCPs varies with time which indicates the risk of leaching of HCH, caused by disturbance of the soil layers and rainwater. Further monitoring of OCPs and PCBs in these locations is necessary for reduction, control and prevention of potential environmental pollution, possibly caused by cleaning of the nearby landfill.

Keywords: Monitoring, Organochlorine pesticides, Polychlorinated biphenyls, Soil pollution, Environmental leaching

DISENTANGLING SOIL PARAMETER EFFECTS ON PESTICIDE FATE BY SIMULATING AMENDMENT-DRIVEN CHANGES

Marija Gadžimuradova*[1]

[1]*Wetsus, European Centre of Excellence for Sustainable Water Technology, *marija.gadzimuradova@wetsus.nl*

Organic amendments introduce a complex mixture of organic matter, nutrients, and microbial by-products to soils, leading to changes in pesticide behavior that are difficult to disentangle in field conditions. To address this, we designed a controlled laboratory study using a single reference soil in which we systematically adjusted individual parameters commonly affected by organic amendment addition: organic carbon source, nitrogen, plant-available phosphorus, and extracellular polymeric substances (EPS).

The objective is to isolate and evaluate the specific influence of each factor on the sorption and degradation of a diverse set of pesticide compounds varying in hydrophobicity and ionizability. This experimental setup allows us to simulate amendment-driven soil changes without introducing the full complexity of real amendments, providing clearer mechanistic insights into how these parameters modulate pesticide fate.

We expect to observe compound-specific responses: for example, increased sorption of hydrophobic pesticides with added organic carbon, and altered degradation dynamics linked to nutrient availability and EPS presence. These findings will contribute to a more predictive understanding of pesticide behavior in amended soils and support the development of targeted, soil- and compound-specific amendment strategies to minimize environmental risks.

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ENVIRONMENTAL BEHAVIOR AND FATE OF BIOPLASTICS IN SOILS

***Sara Adeleh*[1,2]*, *Tabea Becker*[2], *Roland Bol*[1], *Sonja Herres Pawlis*[2], *Thomas Pütz*[1]**

[1]*Institute of Bio- And Geoscience IBG-3: Agrosphere, Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, Jülich, 52425, Germany, *s.adeleh@fz-juelich.de*

[2]*Institute of Inorganic Chemistry, RWTH Aachen University, Landoltweg 1a, Aachen, 52074, Germany*

Transitioning to a circular plastic economy is crucial as global plastic production rises. Conventional plastics, derived from fossil fuels, contribute to carbon emissions and persistent pollution. Bioplastics, made from renewable sources, offer a sustainable alternative by reducing CO_2 emissions and fossil fuel dependence. However, challenges such as recyclability and degradation persist, requiring advanced evaluation techniques.

Plastic breakdown in environments like soil depends on polymer properties and environmental factors. Traditional assessment methods focus mainly on CO_2 emissions, overlooking residual polymer interactions. Carbon-14 (^{14}C) tracing provides a breakthrough by tracking polymer decomposition comprehensively. Polylactic acid (PLA), a widely used biodegradable polymer, is compostable and reduces fossil fuel use. While conventional plastics degrade at less than 1% per year, PLA can degrade within months under optimal conditions.

To enhance understanding, we developed a laboratory-scale synthesis process for ^{14}C-labeled PLA, addressing stereoisomer instability and impurities. This labelled PLA will be studied in sandy and silty soils over 180 days to 12 months, examining the effects of temperature, humidity, and organic manure. Evolved $^{14}CO_2$ will be quantified using Liquid Scintillation Counting (LSC), providing critical insights into PLA's environmental fate and supporting bioplastics' role in a circular economy.

Keywords: Bioplastics, Carbon radiolabeling, Soil, Circular economy, Fate study

Acknowledgements: Thanks to the BioPlastiCycle group for funding project number DBADC435 as work package 5.

BIOCHAR-INDUCED CHANGES IN THE TRANSPORT MECHANISMS OF CHLORINATED PHENOLS IN ALLUVIAL SOIL SYSTEMS

***Tamara Apostolović*[1]*, Marijana Kragulj Isakovski[1], Marko Šolić[1], Jelena Beljin[1], Lutz Weihermüller[2], Snežana Maletić[1]**

[1]University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia,
[*]tamara.apostolovic@dh.uns.ac.rs
[2]Institute of Bio- and Geosciences - IBG-3, Agrosphere Institute, Forschungszentrum Jülich GmbH, Jülich, Germany

This study explores how biochar amendments influence the transport behavior of chlorinated phenols (CPs) in alluvial soils, focusing on the interactions between soil characteristics and the chemical properties of CPs. Through column experiments using both unamended and biochar-amended alluvial soils, the retention and mobility of different CP compounds were assessed. In unamended soils, the primary mechanisms governing CP retention were identified as hydrophobic, polar, and electron donor–acceptor interactions, rather than charge-based mechanisms. However, the nature and extent of retention varied depending on the molecular structure and chemical properties of each compound, such as hydrophobicity, molecular weight, and ionization behavior.

The introduction of biochar into the soil notably altered the transport dynamics of CPs. It enhanced their retention and delayed their movement through the soil matrix, indicating a shift in dominant interaction mechanisms from hydrophobic to more polar-driven processes. This transformation is attributed to the complex surface chemistry and porous structure of biochar, which provides a variety of binding sites that can interact with different functional groups of the pollutants.

These findings highlight the significant role biochar can play in reducing the mobility of organic pollutants in soil, thereby lowering the risk of groundwater contamination. By enhancing pollutant retention and modifying interaction pathways, biochar presents a sustainable strategy for mitigating the leaching of hazardous compounds from contaminated or amended soils. The study underscores the potential of biochar as an effective tool in environmental remediation, particularly for protecting water resources from the long-range transport of organic contaminants.

Keywords: Biochar, Chlorinated phenols, Soil transport, Retention mechanisms

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POSTER SESSION

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DEFORESTATION EFFECTS ON THE SPATIAL DISTRIBUTION OF C AND N IN THE SOILS OF A FORESTED HEADWATER CATCHMENT IN THE EIFEL, GERMANY

***Maia Batsatsashvili*[1]*, Lea Dedden[2], Roland Bol[1], Tim Spieker[1], Gretchen Gettel[3], Inge Wiekenkamp[4], Karsten Kalbitz[5], Thomas Pütz[1]**

*[1]Institute of Bio- and Geosciences Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich, Germany, *m.batsatsashvili@fz-juelich.de*

[2]University of Freiburg, Albert-Ludwigs-Universität Freiburg, Friedrichstraße 39, 79098 Freiburg, Germany, lea.dedden@hydrology.uni-freiburg.de

[3]Department of Ecoscience Aarhus University, 1110, C. F. Møllers Allé 8, Bygning 1110, 8000 Aarhus, Denmark, g.gettel@ecos.au.dk

[4]GFZ Helmholtz Centre for Geosciences, Wissenschaftpark "Albert Einstein", Telegrafenberg, 14473 Potsdam, Germany, inge.wiekenkamp@gfz.de

[5]Institute of Soil Science and Site Ecology TU Dresden, Pienner Strasse 19, 01737 Tharandt, Germany, karsten.kalbitz@tu-dresden.de

Riverine systems are distinct components of the natural environment that have significant roles in storing and processing terrestrial carbon. While processing organic matter, rivers release large amounts of greenhouse gases into the atmosphere. In this light, headwater streams are particularly interesting. Due to their high connectivity with the surrounding landscapes, these small streams are strongly influenced by terrestrial inputs of carbon and nitrogen. The amount and character of C and N inputs to headwater streams are highly dependent on the soil and vegetation type of the catchment.

Since vegetation plays a crucial role in regulating carbon and nitrogen fluxes, the Wüstebach catchment serves as a representative site for studying the impact of land use changes on biogeochemical processes in soil and stream. The Wüstebach catchment, located in the Eifel/Lower Rhine Valley, is a long-term environmental observation site of the TERENO (Terrestrial Environmental Observatories) project. The catchment covers around 38.5 ha in the south-western part of the Eifel National Park. In 2013, nine hectares of Norway spruce have been cleared in the catchment and have been replanted with original beech.

To study deforestation effects on the nutrient fluxes, pools, and spatial distribution of carbon and nitrogen in the soils of Wüstebach three extensive soil sampling campaigns were conducted in the catchment: the first just before clear-cut in 2013, the second after the clear-cut in 2014, and the third, five years after the clear-cut in 2018. The sampling produced high-resolution data on physical and biogeochemical soil parameters per soil horizon.

The aim of this study was to analyze three-dimensional variability of biogeochemical processes in the soils of a forested headwater catchment following partial clear-cutting of a spruce forest.

We will perform geostatistical analysis of the data and produce three-dimensional surface prediction models of the spatial distribution of the two nutrients C and N in 2013, 2014, and 2018 over the entire catchment and show changes in C and N stocks caused by clear-cut.

Keywords: Carbon and nitrogen cycling, Land use change, Deforestation, Soil nutrient fluxes

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BIOCHAR-BASED ELECTROCHEMICAL SENSORS FOR PESTICIDES DETECTION IN AQUATIC ENVIRONMENT

***Jasmina Anojčić*[1]*, Sanja Mutić[1], Nina Đukanović[1], Tamara Apostolović[1], Tajana Simetić[1], Tijana Marjanović Srebro[1], Jelena Beljin[1]**

*[1]Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia, *jasmina.anojcic@dh.uns.ac.rs*

As the research and the applications of electrochemical sensors continue to develop, a single-handed pursuit of accuracy and sensitivity cannot meet the demands of the analysis in many *in situ* or *point-of-care* testing circumstances, especially in the fields of food analysis, clinical diagnosis, environmental monitoring, and agricultural detection. More cost-effective, stable, and versatile electrodes, as well as more stable and repeatable sensing strategies, are needed. The peculiar properties of biochar were exploited for the development of electrochemical sensors in view of its lower environmental footprint compared to the widely investigated synthetic carbonaceous nanomaterials (e.g., carbon nanotubes, graphene oxide and carbon dots), reaching analogous or even better analytical performances in the field of electrochemical sensing. With the growth of green chemistry concepts, the preparation and application of biochar have been receiving increased attention. In addition to its advantages (i.e., amorphous characteristics, large specific surface area, surface charge, and good stability etc.), biochar has highly reactive and surface-functionalized spherical and porous structures. Therefore, biochar is a good candidate as a material for electrodes fabrication or modification. The aim of the present work was to develop rapid and highly sensitive voltammetric methods based on the use of biochar-modified carbon paste electrodes for determination of selected dithiocarbamate and carbamate fungicides (maneb, mancozeb and carbendazim). The biochar from different sources (hardwood, wheat, corn) was produced and characterized, afterward it was applied for the preparation of environmentally friendly electrodes with improved electroanalytical performance compared to existing ones. Under optimized conditions of adsorptive stripping voltammetric methods, the obtained limit of detection was 15.0 μg L^{-1} for maneb, 7.5 μg L^{-1} for mancozeb, and 0.38 μg L^{-1} for carbendazim. The developed voltammetric methods were successfully applied to determine selected fungicides in environmental water samples (spiked river water, surface water and wastewater), with good recovery and reproducibility.

Keywords: Biochar, Carbon paste electrode, Voltammetry, Fungicides, Environmental water samples

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential–EnviroChar.

SOIL NUTRIENT AVAILABILITY AND AGGREGATE DYNAMICS UNDER DITCH-BURIED ORGANIC MATERIALS IN A WHEAT-BASED ROTATION SYSTEM

Zhenzhen Li[1,2], Nina Siebers[2], Roland Bol[2]*, Wulf Amelung[1,2,3]*, Haishui Yang[1]*

[1]College of Agriculture, Nanjing Agricultural University, Nanjing 210095 China

[2]Forschungszentrum Jülich, IBG3, 52428 Jülich, Germany

[3]Soil Science and Soil Ecology, University Bonn, Bonn, Germany

Sustainable soil management is imperative to address global food demand while minimizing environmental degradation, particularly in wheat-based systems where intensive cultivation often causes a lot of waste of straw resources, which will deplete soil nutrients and disrupt aggregate stability. Therefore, we designed an experiment to investigate the long-term effects of deep incorporation of straw and compost on soil structure, nutrient mobility (C, N, P, S, Fe, Ca, Mg), and aggregate stability across two contrasting agroecosystems in China and Germany. By stratifying soil into topsoil and subsoil layers, we evaluate how organic amendments alter vertical nutrient distribution, physical properties, and microbial activity under varying climatic and edaphic conditions. Field experiments employ a split-plot design, comparing control plots with straw- and compost-amended treatments. Key metrics include soil organic carbon (SOC) pools, nutrient leaching potentials, water-stable aggregate proportions, and enzymatic activities. Preliminary data from China suggest that deep burial enhances SOC sequestration and increases N retention in the subsoil. Meanwhile, the deep burying of straw promoted the subsoil to retain more nutrients and was conducive to the formation of large aggregates. Notably, subsoil in amended plots shows improved water-holding capacity, likely mitigating nutrient leaching risks. Cross-regional comparisons may reveal climate-driven disparities in amendment efficiency. These findings underscore the potential of deep amendment strategies to rehabilitate degraded subsoils, optimize nutrient cycling, and support region-specific sustainable soil management.

Keywords: Aggregate stability, Subsoil amelioration, SOC sequestration, Nutrient migration

Acknowledgements: The China Scholarship Council

ESTABLISHING A SOIL HEALTH BASELINE FOR GREEN INFRASTRUCTURE: SAMPLING NATURAL AND SEMI-NATURAL AREAS IN AGRICULTURAL LANDSCAPES

Kristina Kalkan[1], Sreten Terzić[1], Maja Arok[1], Andrijana Andrić[1], Predrag Lugonja[1], Liljana Šašić Zorić[1], Tijana Nikolić Lugonja[1]*

*[1]Biosense Institute, University of Novi Sad, dr Zorana Đinđića 1, Novi Sad, Serbia, *tijana.nikolic@biosense.rs*

Soil health plays a crucial role in achieving the UN Sustainable Development Goals (SDGs), particularly Zero Hunger and Life on Land. As global efforts to meet these objectives intensify, the need for openly accessible soil data and capacity building in its use becomes increasingly urgent. The SONATA project in Serbia aims to facilitate knowledge transfer and skill development among its partners to address the impacts of climate change. The project specifically examines green infrastructure within and around agricultural landscapes, exploring how contextual green datasets can be leveraged to inform the optimal allocation of Nature-based Solutions (NbS). While beneficial, soil monitoring is far more common in intensively managed arable land than in natural habitats. The primary goal of the SONATA soil study is to assess soil health within regional green infrastructure, focusing on the natural and semi-natural areas of Vojvodina. The specific objectives are to: Systematically identify representative research locations, considering the diversity of Vojvodina's natural infrastructure, AND Conduct soil sampling to ensure proportional coverage of the entire study area. So, to ensure a systematic and proportional approach, we applied the LUCAS (Land Use and Coverage Area frame Survey) methodology, an EU standard for characterizing land cover and land use. Sampling area selection was conducted using machine learning techniques, incorporating spatial clustering and optimization to identify representative sites. This approach resulted in the selection of 23 forest and 39 grassland locations. At each location, we identified three sites for composite soil sampling, following the SoilBON methodology (the global Soil Biodiversity Observation Network). Each composite sample was created by mixing subsamples collected from nine points within a 30×30 m square. This process resulted in a total of 186 soil samples, distributed across four grassland clusters and four forest cover clusters. This sample collection enables us to plan and conduct a comprehensive soil health assessment based on a range of properties, including soil texture, structure, compaction, moisture, pH, nutrients, and soil microbial diversity. The resulting dataset will be integrated into the BIOS-Natural-Soil database, serving as a unique baseline dataset and a reference system for the future restoration of degraded agricultural land. Additionally, the obtained data, combined with landscape diversity indicators, will support informed spatial planning and directly contribute to the sustainable development of Vojvodina's agricultural landscape. The development and continuous expansion of this database will enhance our ability to assess Vojvodina's natural resource capacity in mitigating the effects of climate change.

Keywords: Soil health, Natural areas, Data collection, Framework development

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MACRONUTRIENT (NPK) CONTENT IN DIFFERENT TYPES OF ORGANIC FERTILIZERS

***Nikolina N. Dizdar*[1]*, Ranko R. Čabilovski[2], Snežana P. Jakšić[1], Stanko B. Milić[1], Milorad S. Živanov[1], Dunja P. Anđelić[1], Aleksandar Ž. Mihaljev[1]**

[1]*Institute of Field and Vegetable Crops, Laboratory for Soil and Agroecology, Maksima Gorkog 30, 21000 Novi Sad, Serbia, *nikolina.dizdar@ifvcns.ns.ac.rs*

[2]*University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia*

The shift toward sustainable agricultural practices emphasizes the importance of organic fertilizers as a viable alternative to synthetic inputs. This study evaluated the nutrient composition of organic fertilizers, focusing on nitrogen (N), phosphorus (P), and potassium (K), essential for soil fertility. From 2022 to 2024, 90 samples were analyzed, encompassing substrates, pelleted animal-based fertilizers, and manure. The study utilized standardized methods, including CNS elemental analysis for nitrogen, ICP-OES and spectrophotometry for phosphorus, and flame photometry for potassium. The findings demonstrated considerable variability in macronutrient concentrations among the fertilizer types. Dehydrated (pelleted) animal-based fertilizers exhibited the highest nutrient levels, with nitrogen around 4%, phosphorus 3%, and potassium up to 4%. In contrast, manure displayed lower but notable values, with N, P, and K concentrations reaching up to 2%, while substrates showed minimal nutrient levels, not exceeding 1%. These results underscore the potential of organic fertilizers in enhancing soil fertility while reducing reliance on synthetic fertilizers. Their integration into agricultural practices promotes nutrient recycling and minimizes environmental impact, supporting the broader objectives of sustainable agriculture and integrated soil management. This study confirms the role of organic fertilizers as a cornerstone for achieving long-term agricultural sustainability.

Keywords: Organic fertilizers, Macronutrients, Soil management

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FUTURES OF PLANT-SOIL NITROGEN CYCLING FEEDBACKS UNDER GLOBAL CLIMATE CHANGE – CRITICAL EXPERIMENTAL ASSESSMENT USING THE LARGE-SCALE MESOCOSM RESEARCH FACILITY AGRASIM

Sijia, Wang*[1]

*[1]Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich, Germany, *s.wang@fz-juelich.de*

Human activities have led to atmospheric nitrogen deposition, global warming, and increased CO_2 concentrations over the past several decades. Nitrogen is one of the most important and limiting nutrients in ecosystems. It provides essential materials and energy for the growth of living organisms. It has been shown that high temperature and high CO_2 concentration have a synergistic effect on plant biomass, photosynthesis, and belowground nitrogen partitioning; changes in precipitation can significantly affect plant uptake of nitrogen in the soil; and warming further enhances the promotion of soil enzyme activity and organic nitrogen mineralization by high CO_2 concentration. To summarize, plant-soil N cycling under global climate change has become a concern for many scientists, but the feedback process of plant-soil N cycling to climate change is still unclear.

Most of the current studies focus on the effects of a single climate change factor on the plant-soil nitrogen cycle. However, climate change factors often interact with each other, and the complex interactions among these factors may lead to different or unpredictable results compared to those of a single factor. Therefore, an in-depth study of the plant-soil N cycling process and its feedback mechanism under multi-factor interactions can provide a theoretical basis for scientifically and rationally predicting the N demand of crops in farmland ecosystems under future climate conditions, as well as ensuring the stable supply of crop yields, which is of great significance for a comprehensive understanding of the N cycling process in farmland ecosystems under the background of global climate change and sustainable use of soils. And AgraSim, a large-scale agricultural climate change simulator built at Forschungszentrum Jülich, Germany, is already in operation. It could provide a favorable environment for studying the feedback mechanism of the plant-soil nitrogen cycle under future climate change.

Keywords: Plant-soil nitrogen cycling, Global climate change, AgraSim

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INDUSTRIAL COMPOST - SOIL ENHANCER IN MAIZE PRODUCTION

***Milorad S. Živanov*[1]*, Srđan I. Šeremešić[2], Jovica R. Vasin[1], Stanko B. Milić[1], Bojan Đ. Vojnov[2], Nikolina N. Dizdar[1], Dunja P. Anđelić[1]**

[1]*Institute of Field and Vegetable Crops, Laboratory for Soil and Agroecology, Maksima Gorkog 30, 21000 Novi Sad, Serbia, *milorad.zivanov@ifvcns.ns.ac.rs*

[2]*University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia*

Due to a reduction in livestock populations, Europe has experienced a shortage of organic fertilizers, particularly manure. Consequently, soil degradation has occurred in terms of a decrease in organic matter content. As appropriate substitute for manure, materials such as biochar, digestate, and compost can be utilized. This study used compost produced industrially in specialized facilities under controlled conditions. Three-year field trials were conducted at three different locations representing three distinct soil textures (clay, loam, and sandy soils). Compost was applied in increasing doses across five treatments, ranging from 1.2 to 14.4 t/ha. The applied material was three times more concentrated in nutrients compared to the average content found in manure. Corn was cultivated in the trials.

A highly significant effect of compost application was observed on several soil properties, including bulk density, pH, total carbon content, C/N ratio, labile carbon fraction, nitrate content, potassium content, and microbial number (*Azotobacter*, ammonifiers, oligonitrotrophils, fungi, and *Actinomycetes*). Furthermore, compost application had a highly significant impact on corn grain yield.

Based on these findings, it can be concluded that the results met expectations, and the organic material used can serve as a viable alternative to manure when properly prepared.

Keywords: Organic amendment, Maize, Fertilizing, Compost

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SOIL HEALTH – AN EVIDENCE FOR THE BIOGEOCHEMICAL INDICATORS ON REGIONAL VS. GLOBAL SCALE

***Aleksandar Piperevski*[1]*, *Biljana Balabanova*[1]**

[1]*Faculty of Agriculture, Goce Delcev University, Krste Misirkov 10A, 2000 Stip, Republic of North Macedonia,*

**apiperevski@yahoo.com*

Soil health is a critical component of sustainable agriculture and environmental management. This study evaluates biogeochemical indicators of soil health, comparing regional data from N. Macedonia with global standards. Indicators such as soil organic carbon (SOC), nutrient levels (nitrogen, phosphorus, potassium), pH, conductivity, and microbial biomass were analyzed. Data were collected from various soil health monitoring programs and research studies. The results highlight significant regional variations in soil health indicators in N. Macedonia compared to global averages. The comparison reveals that at the global scale we have an advanced and integrated approach, and the Republic of N. Macedonia should make additional efforts to harmonize and implement global standards and practices. In the Republic of N. Macedonia, regulations and soil health monitoring are in the process of development and alignment with European and global standards. This study provides recommendations for improving the national framework and practice in order to achieve more effective protection and sustainable management of soil resources. Also, this study highlights the global significance of localized data in developing effective soil management strategies and demonstrates the value of biogeochemical indicators at both regional and global scales.

Keywords: Soil health, Biogeochemical indicators, Soil management

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REGIONAL DIFFERENCES OF IPCC TIER 1 AND TIER 2 FACTORS IN LITHUANIAN CROPLANDS

***Žygimantas Kidikas*[1,2]*, Rytis Skominas[1], Vilma Naujokienė[1]**

[1]*Vytautas Magnus University, Faculty of Engineering, Kaunas, Lithuania, *zygimantas.kidikas@vdu.lt*

[2]*SME Biovala, Kaunas, Lithuania*

Understanding soil carbon dynamics in historic cropland remaining cropland in mineral soils is crucial for accurate greenhouse gas (GHG) inventories and climate change mitigation efforts. The Factor of Land Usage (FLU) offers a quantitative measure of carbon retention or loss attributable to long-term management practices. The comparison of Tier 2-generated FLU estimates often deviate from Tier 1 defaults, revealing the potential underestimation or overestimation of soil organic carbon (SOC) stocks when relying solely on generalized values. Study aimed Lithuanian crop soils, to compare the predictive accuracy of Tier 1, which uses default Intergovernmental Panel on Climate Change (IPCC) values, against Tier 2, which employs region-specific data to more accurately estimate FLU coefficients. Through the initial field analysis of 7339 ha croplands in 5 different regional mixed farms at the beginning of 3 years monitoring campaign, we determined main influence factors and best practices applied for SOC forecasting. For historic cropland, primary results according to Tier 1 - no practices applied, Tier 2 - reduced tillage and Tier 2 - no-tillage management, displays SOC changes of 0.2061, 0.2226 and 0.2370 t C $ha^{-1}yr^{-1}$, respectively. While implementing Tier 2, forecasts necessitate additional resources and data to provide a more refined assessment of GHG emissions under individual farming activities. Our results indicate that adopting Tier 2 data can strengthen the scientific basis on increasing carbon sequestration, measurement, reporting and verification of SOC and decisions concerning land management. Future work should integrate higher- resolution 3-year monitoring datasets to refine FLU estimates, enhancing national and global efforts in climate change mitigation.

Keywords: Soil carbon, Carbon sequestration, IPCC, Cropland

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IMPACT OF pH ON THE EFFICIENCY OF COAGULATION IN REMOVING MICROPLASTICS AND TEXTILE FIBERS FROM WATER

***Sanja Vasiljević*[1]*, Tijana Marjanović Srebro[1], Maja Vujić[1], Jasmina Agbaba[1], Radivoj Tomić[1], Aleksandra Tubić[1]**

[1]*University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia,*
**sanjav@dh.uns.ac.rs*

Coagulation and flocculation are widely applied physicochemical methods for removing microplastics from water. The presence of microplastics in wastewater demands specific process modifications to enhance treatment efficiency. Key factors influencing the coagulation-flocculation process include coagulant type and dose, pH value, and the physicochemical properties of both microplastics and the water matrix - such as the presence of organic matter and surfactants. Among these, pH plays a critical role by influencing the surface charge of particles and the hydrolysis behavior of coagulants, directly affecting floc formation and pollutant removal. This study aimed to assess the impact of pH adjustment on the removal efficiency of various microplastics and textile fibers from washing machine effluent. The tested materials included polyethylene (PE), polyvinyl chloride (PVC), synthetic textile fibers (PEST), and a mixture of synthetic and natural (cotton) fibers. Two coagulants – ferric chloride ($FeCl_3$, 20–220 mg/L) and polyaluminum chloride (PACl, 10–50 mg/L) – were applied under different pH conditions. The results revealed a heterogeneous response among the tested materials. For PE particles, pH adjustment improved removal efficiency at nearly all coagulant doses, particularly with $FeCl_3$. However, PVC particles showed limited sensitivity to pH changes, except at the lowest $FeCl_3$ dose (20 mg/L), where a notable increase in removal was observed. This behavior likely stems from differences in density and surface chemistry between PE and PVC. For synthetic textile fibers (PEST), pH modification consistently enhanced removal efficiency across all coagulant doses. In contrast, mixed fibers containing cotton responded positively only at higher coagulant concentrations. This difference is attributed to the structural properties of the fibers –synthetic fibers exhibit higher density, a more uniform surface, and lower water absorption capacity, making them more prone to coagulation compared to porous, hydrophilic natural fibers. Overall, the findings confirm that effective microplastic and fiber removal via coagulation depends on both process parameters and material-specific properties. While optimizing pH and coagulant dose is crucial, equal attention must be given to the nature of the target pollutants and the water matrix. These insights underline the importance of tailoring treatment strategies to the type of microplastics and textile fibers present, particularly when addressing complex wastewater streams such as laundry effluents.

Keywords: Microplastics, Textile fibers, Coagulation, Removal efficiency

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ENVIROMENTAL IMPACT OF BIOCHAR APLICATION

Stefan R. Mijatović*[1]*, Tamara B. Apostolović[1], Snežana P. Maletić[1], Srđan D. Rončević[1], Marijana M. Kragulj Isakovski[1], Nina S. Đukanović[1], Jelena M. Beljin[1]

[1]University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia,

**mijatovic96stefan@gmail.com*

Biochar is a material obtained through the pyrolysis of organic materials, such as plant waste, wood residues, and agricultural by-products, at high temperatures in low oxygen conditions. The precursor or biomass can be municipal waste, crop residues, animal manure, or industrial waste. The pyrolysis temperature ranges between 300 and 1000°C. By modifying the pyrolysis temperature, the characteristics of biochar can be adjusted for different applications. For example, the presence of biochar in soil can either reduce or stimulate plant growth, depending on the characteristics of the biochar and the pyrolysis process used. Biomass mainly consists of organic substances like cellulose, hemicellulose, lignin, and small amounts of inorganic materials. This process ensures that carbon dioxide and other harmful gases are not released into the atmosphere, making biochar an effective tool for carbon sequestration and reducing the greenhouse effect. The application of biochar in agriculture improves soil quality by increasing water retention capacity, enhancing fertility, reducing erosion, and boosting biological activity in the soil. Additionally, biochar is used for the remediation of contaminated soils as it has the ability to absorb heavy metals, pesticides, and other pollutants, improving the quality of polluted areas. Its long-term stability in the soil provides lasting benefits in reducing greenhouse gas emissions and improving agricultural practices. Given its ecological benefits, biochar is considered a sustainable solution for reducing climate change, improving agricultural practices, and cleaning up contaminated lands. Its application offers numerous environmental benefits and potentially serves as a key tool in sustainable development.

Keywords: Biochar, Pyrolysis, Soil quality, Environmental application

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ENVIRONMENTAL FATE OF MELAMINE: BIOTRANSFORMATION IN SOIL SYSTEMS

***Irina Jevrosimov*[1]*, Jessica Drozdz[2], Michael Zumstein[2], Gabriel Sigmund[3], Thorsten Hüffer[2], Thilo Hofmann[2], Snežana Maletić[1]**

*[1]Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 3, 21000 Novi Sad, R. Serbia, *irinaj@dh.uns.ac.rs*

[2]Department of Environmental Geosciences, Centre for Microbiology and Environmental Systems Science, University of Vienna, Josef-Holaubek-Platz 2 (UZA II), 1090 Vienna, Austria

[3]Wageningen University & Research, Netherland

We are regularly exposed to a wide range of chemicals found in industrial processes, household products, and everyday environments, which can impact our health and surroundings in various ways. One such chemical is melamine, which belongs to the group of heterocyclic organic compounds and has a wide range of applications, including as a superplasticizer, in paints and coatings, and for fire-resistant foams, among others. This study investigates the biotransformation of melamine in two soils and two organic soil amendments (OSA). Experiments were conducted with two organic soil amendments: cow manure and sewage sludge, and two soils: Bayreuth soil and Danube sediment. The experimental setup includes enzyme extraction, incubation of melamine in enzyme extracts, and LC-MS/MS analysis of samples taken at selected time points during these incubations. Results indicate no biotransformation of melamine in the tested soils, which might be due to low enzyme abundance in soils, low enzyme extraction efficiency, or limited potential of enzymes to transform melamine. Incubating melamine with OSA showed its interaction with organic matter, which might be explained by the fact that melamine contains polarized amino groups (-NH_2) that can form hydrogen bonds with components of organic matter.

Keywords: Biotransformation, Organic soil amendments (OSA), Soils, Melamine

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THE CONTENT OF ORGANIC MATTER, ORGANIC CARBON AND C/N RATIO IN DIFFERENT TYPES OF ORGANIC FERTILIZERS

Dunja P. Anđelić*[1]*, Snežana P. Maletić[2], Snežana P. Jakšić[1], Stanko B. Milić[1], Milorad S. Živanov[1], Nikolina N. Dizdar[1], Aleksandar Ž. Mihaljev[1]

*[1]Institute of Field and Vegetable Crops, Laboratory for Soil and Agroecology, Maksima Gorkog 30, 21000 Novi Sad, Serbia, *dunja.andjelic@ifvcns.ns.ac.rs*

[2]University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia

The content of organic matter in soil is not only crucial for soil quality and the increase of organic matter but also for agricultural production. The aim of this research was to examine the content of organic matter, the C/N ratio, and the carbon content in organic fertilizers (dehydrated animal-based organic fertilizer, compost, and manure) and to investigate whether their application is a suitable solution for increasing organic matter content in the soil. A total of 60 samples and three types of organic fertilizers were analyzed over the period from 2021 to 2024. The values for organic matter ranged from 1.46% to 87.25%, the C/N ratio ranged from 3.63% to 19.68%, and the values for organic carbon ranged from 0.822% to 44.12%. Based on the research, it can be concluded that soil organic matter has a significant impact on most physical, chemical, and biological soil characteristics. Additionally, based on the analysis of different types of organic fertilizers, it was observed that the obtained values vary significantly, as the fertilizers are mostly sourced from different households and lack precise declarations of the analyzed parameters. Therefore, chemical analysis of fertilizers is necessary to determine the correct application rate for agricultural land.

Keywords: Organic fertilizer, Organic matter, Organic carbon, Soil

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DETERMINATION OF GLYPHOSATE RESIDUES IN THE DTD CANAL IN NOVI SAD

***Milica Škorić*[1]*, Vojislava Bursić[2], Sonja Gvozdenac[1]**

*[1]Institute of Field and Vegetable Crops, National Institute of the Republic of Serbia, Maksima Gorkog 30, 21 000 Novi Sad, Serbia, *milica.skoric22@gmail.com*

[2]Department of Plant and Environmental Protection, Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia

Glyphosate is a non-selective systemic herbicide used to control a wide range of annual, biennial, and perennial weeds in agriculture, plantations/orchards/forestry, industry, and urban areas. It is commonly used to control weeds both in agricultural and non-agricultural areas. Due to its widespread use, it is often found in groundwater and surface waters. The aim of the research was to examine the presence of glyphosate in irrigation canals in Novi Sad, depending on the seasons. Water samples were collected from the DTD canal in the territory of Novi Sad. The water was sampled using a telescopic sampler. Sample preparation involved acidifying the samples to convert the glyphosate into a soluble form, followed by neutralizing the sample, derivatizing it using FMOC-Cl, and concentrating it using SPE columns. The analysis of glyphosate residues in real samples was performed using the LC-ESI-MS/MS method, with prior validation of the method through two procedures for their determination (direct procedure and derivatization method), aimed at defining the dynamics of the analyzed compound (glyphosate). According to the obtained results, glyphosate was present in all tested water samples. The concentration range of average glyphosate values in the water samples from the canals varied depending on the season.

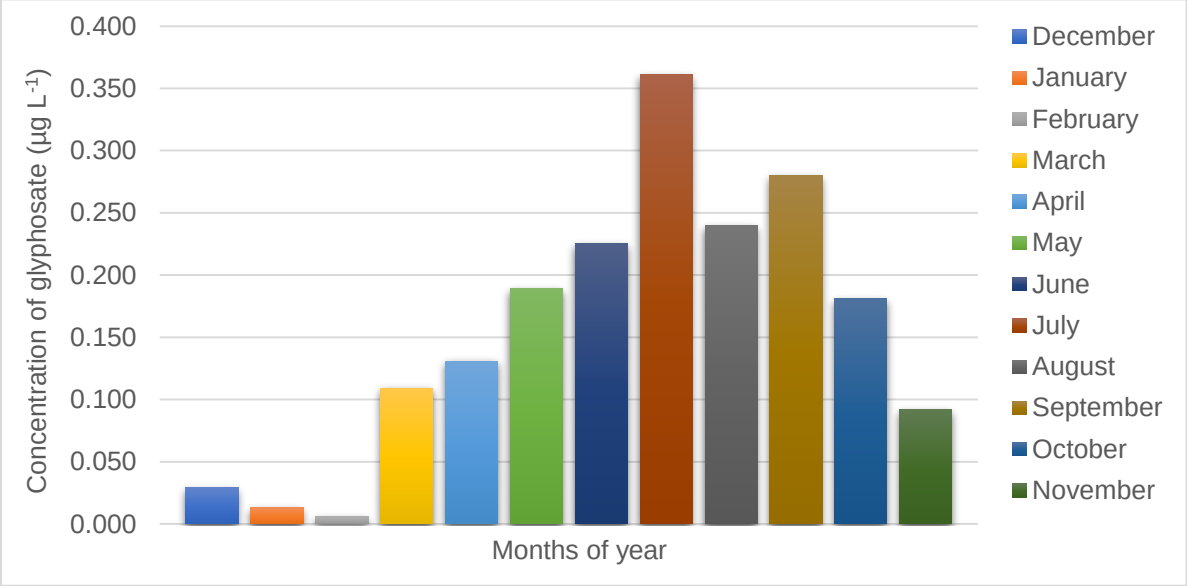

Figure 1. Content of glyphosate in canal DTD in Novi Sad

Keywords: Glyphosate, Water, DTD canal

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COMPARISON OF TWO METHODS FOR EXTRACTION CONTAMINANTS OF EMERGING CONCERN FROM SOIL SAMPLES

***Dušan Rakić*[1]*, Igor Antić[1], Jelena Živančev[1], Maja Buljovčić[1], Zita Šereš[1], Nataša Đurišić Mladenović[1]**

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia,*

rakic.11.20.d@uns.ac.rs

Contaminants of emerging concern (CECs) are unregulated, infrequently monitored synthetic or natural substances that have been shown or suspected of negatively impacting human and environmental health. CECs include many different classes of compounds, such as pharmaceutically active compounds (PhACs), personal care products, illicit drugs, hormones, pesticides in current usage, per- and poly-fluoroalkyl substances (PFAS), micro- and nano-plastics, and many others. The fate of CECs in the environment depends on their physical and chemical properties and environmental conditions. Since surface water receives most wastewater discharges, its use for irrigation can further transport many CECs to agricultural soils. Because plants tend to uptake organic and inorganic substances from the soil, the presence of CECs in agricultural areas has raised concerns about their potential introduction into the food chain.

This study aims to compare the efficiency of the two most frequently used methods for CECs extraction from soil samples, so-called Quick, Easy, Cheap, Effective, Rugged, and Safe (QuEChERS) and Accelerated Solvent Extraction (ASE), also known as pressurized liquid extraction (PLE), on a selected CECs compound (PhACs, PFAS, and pesticides). Target analysis of CECs in soil extracts was performed using ultra-high-performance liquid chromatography coupled with tandem mass spectrometry. The comparison was based on method validation parameters such as contaminants recovery, limits of quantification, and matrix effect. QuEChERS extraction has shown better extraction efficiency than ASE for most selected compounds, proving its importance for wide-range screening of soil contamination.

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PHYTOREMEDIATION POTENTIAL OF ENERGY CROPS AND PGPR INOCULANTS FOR THE REMEDIATION OF CONTAMINATED SOILS

***Ivana Bajić*[1]*, Snežana Maletić[2], Tijana Zeremski[1], Marijana Kragulj Isakovski[2], Nina Đukanović[2], Irina Jevrosimov[2], Stanko Milić[1]**

[1]*Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia, *ivana.bajic@ifvcns. ns.ac.rs*

[2]*Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia*

Conventional soil remediation technologies are often expensive and may negatively affect the soil quality. Using energy crops and associated microbes as phytoremediation tools presents a sustainable, cost-effective alternative for mitigating soil contamination.

In this study, three energy crops–Cannabis sativa (hemp), Sorghum halepense (forage sorghum), and Medicago sativa (alfalfa)–were cultivated in pots containing soil collected from three contaminated locations: Bikovo (sewage sludge contamination), Srpski Itebej (heavy metal contamination), and Futog (diesel fuel contamination). Some treatments were treated with Plant Growth-Promoting Rhizobacteria (PGPR) bacterial and fungal inoculants.

Post-harvest soil analyses revealed significant variations in chemical properties across treatments. The soil reaction (pH) ranged from neutral (observed in samples from the heavy metal variant/location) to slightly alkaline (found in the other two variants/locations). The humus content in all treatments exceeded 3%, while total nitrogen (N) content followed a similar trend to organic matter. The highest available phosphorus values were identified in treatments with PGPR amendments, across nearly all variants/locations. The highest total organic carbon (TOC) values are detected in the Sorghum/Diesel/Fungal PGPR variant (2.65%), while the lowest values were observed in Alfalfa/Diesel variant (1.74%).

The obtained results contribute to investigate the phytoremediation potential of three plant species (Forage Sorghum, Hemp, Alfalfa) and to understanding the effectiveness of PGPR in enhancing the remediation of contaminated soils.

Keywords: Energy crops, Contaminated soils, Phytoremediation

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, # 6769, Natural based efficient solution for remediation and revitalization of contaminated locations using energy crops – ReNBES.

THE POTENTIAL OF FIELD CROPS FOR PHYTOEXTRACTON OF HEAVY METALS FROM DREDGED SEDIMENT

***Nadežda Stojanov*[1]*, Jelena Beljin[2], Snežana Maletić[2], Nina Đukanović[2], Tijana Zeremski[1]**

[1]Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia,

[*]nadezda.stojanov@ifvcns.ns.ac.rs

[2]Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia

Dredged sediment has the potential as a soil amendment due to its high organic matter and nutrient content, which improves soil structure and microbiological properties. However, its potential contamination with heavy metals presents a challenge. Phytoextraction of heavy metals by field crops, followed by the removal of above-ground biomass after harvest, is an approach for remediating contaminated sediment.

This study assessed the potential of three crops–rapeseed (*Brassica napus*), hemp (*Cannabis sativa*), and sorghum (*Sorghum bicolor*)–for heavy metal accumulation from dredged sediment. The crops were grown in pots filled with sediment (Cd, Cr, Cu, Pb) from the Begej Canal in Serbia, under semi-controlled open-air conditions. The heavy metal content in plants was analyzed using microwave digestion, followed by ICP-MS analysis.

The results showed that copper accumulated the most in all three crops. Industrial hemp accumulated the highest level of copper (49.3 µg) and chromium (32.2 µg), while rapeseed showed the highest accumulation of cadmium (8.2 µg) and lead (8.8 µg) per plant. Hemp produced the highest biomass, followed by rapeseed, while sorghum had the lowest and thus the lowest heavy metal accumulation.

For phytoextraction purposes, crops with higher biomass are preferable to maximize the total amount of accumulated heavy metals. Rapeseed and hemp can be effectively used as crops for heavy metal phytoextraction from contaminated dredged sediment.

Keywords: Dredged sediment, Heavy metals, Phytoextraction, Field crops

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REMOVAL OF MANGANESE IONS FROM WATER USING MAGNETITE NANOPARTICLES

***Nenad Grba*[1]*, Mirjana Petronijević[2], Sanja Panić[2], Jelena Tanasić[2], Slavica Ražić[3]**

[1]*Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovica 3, 21102 Novi Sad, Serbia,*

**nenad.grba@dh.uns.ac.rs*

[2]*Faculty of Technology Novi Sad, University of Novi Sad, Boulevard cara Lazara 1, 21101 Novi Sad, Serbia*

[3]*Faculty of Pharmacy, University of Belgrade, Vojvode Stepe 450, 11221 Belgrade, Serbia*

Magnetic nanoparticles (MNPs) represent a category of nanomaterials whose behavior can be controlled through magnetic fields, showcasing substantial potential across diverse environmental applications. Among these, magnetite nanoparticles (Fe_3O_4) are particularly prevalent due to their low toxicity and favorable biocompatibility. Typically, pristine MNPs are synthesized from iron salts via the co-precipitation method in an alkaline medium. Magnetite particles were known as good adsorbents which demonstrated high effectiveness for eliminating metal ions from water. This study explores the utilization of commercial magnetite nanoparticles (CAS: 1317-61-9) as an adsorbent for the removal of manganese ion (Mn^{2+}) from groundwater with relatively high Mn^{2+} content (600 µg/L). Research was conducted on groundwater from the territory of the city of Laktaši, Republic of Srpska, Bosnia and Herzegovina, which is used for water supply to the population. Using the magnetite nanoparticles in a concentration of 5 g/L, a manganese ion removal efficiency of 98% is achieved after 1 hour of water treatment. The Mn^{2+} content remaining in the groundwater after treatment is 13.0 µg/L, achieving the values for manganese ion content in drinking water prescribed by the regulations of the Republic of Serbia (< 50 µg/L) (Official Gazette SRJ, No. 42/98 and 44/99; Official Gazette RS, No. 28/2019). The high efficiency of using magnetite particles for the removal of manganese ions highlights the potential of this material for use as an adsorbent in water purification.

Keywords: High cost-efficiency material,Groundwater treatment, Adsorption tests

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 7464, Novel Bio-linked Magnetite/geopolymer Composites in Phenol-containing Wastewater Treatment: Toward Zero-waste Technology - BioCompWaterClean.

SMART4ENV PROJECT: ENHANCING THE SCIENTIFIC CAPACITY OF TUBITAK MAM IN THE FIELD OF SMART ENVIRONMENTAL TECHNOLOGIES FOR CLIMATE CHANGE CHALLENGES

***Burcu Kiran*[1]*, Selda Murat-Hocaoglu[1], Sebnem Aynur[1], Fatone F.[2], Salas, S.P.[3], Maletsky, Z.[4], Piccinetti, L.[5]**

*[1]TUBITAK Marmara Research Center, Vice Presidency of Climate Change and Life Sciences, Baris Mah. 41400, Gebze, Kocaeli, Türkiye, *burcu.uyusur@tubitak.gov.tr*

[2]Università Politecnica delle Marche (UNIVPM)

[3]Fundacio Universitaria Balmes (UVIC-UCC)

[4]Norges Miljo-Og Biovitenskaplige Universitet (NMBU)

[5]Sustainable Innovation Technology Services Limited (SITES)

SMART4ENV Project aims to enhance R&I capabilities in smart environmental solutions for climate change adaptation while improving management skills and governance. It has received funding from EU's Horizon Europe Widera 2021 Call under Grant Agreement No 101079251. In the research component of the Project, a smart farming irrigation system is being built using a combination of an Edge Control, a WiFi component water potential sensors and motorized ball valves. All subsystems used in this research are designed by using commercial components. In this way, soil water and other chemical constituents (to be determined subsequently) will be measured in real time. The current research has the potential to relate with the topic "Fate and Transport of Emerging Pollutants from Organic Soil Amendments in Agricultural Soils" in two ways. First, it has the potential to investigate how emerging pollutants' fate and transport change in different water contents of the subsurface media. Second, the laboratory smart irrigation setup can be used with marginal irrigation waters (e.g., domestic wastewater or saline waters), and the effects of marginal irrigation waters can be investigated in terms of soil and groundwater pollution.

Keywords: Irrigation, Digitalization, Sensor, Soil moisture content

Acknowledgements: This study was supported by the European Union Horizon Research and Innovation Program under the SMART4ENV (Enhancing the Scientific Capacity of TUBITAK MAM in the Field of Smart Environmental Technologies for Climate Change Challenges) project Grant Agreement No. 101079251.

ADVANCED SPATIAL MODELING FOR METALS DISTRIBUTION DUE TO THE LONGTIME MINING ACTIVITIES

***Biljana Balabanova*[1]*, *Trajče Stafilov*[2], *Robert Šajn*[3]**

[1]*Faculty of Agriculture, Goce Delčev University, Krste Misirkov No. 10-A, 2000 Štip, Republic of Macedonia, *biljana.balabanova@ugd.edu.mk*

[2]*Institute of Chemistry, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, POB 162, 1000 Skopje, Macedonia*

[3]*Geological Survey of Slovenia, Dimičeva ulica 14, 1000 Ljubljana, Slovenia*

The main purpose of this study was to develop a visualisation model of spatial distribution using linear and nonlinear mathematical methods that combine a chemical analysis and various geospatial parameters in the Bregalnica River Basin, Kriva Reka River Basin, and the area of the field Ovče Pole, Republic of Macedonia. The study points to critical anomalies of the linear methods correlated to their concentrations depending on the spatial distance. The most commonly used geostatistical prediction method is kriging that uses the semivariance function. Various parameters can influence the results, which can lead to the wrong interpretation most common are Bull's eye contours. On the other side Artificial Neural Network – Multilayer Perceptron (ANN-MLP) improved much better results. ANN-MLP was used as a nonlinear model for data processing and visualization of lead and copper in the investigated area. The model obtained by ANN was tested for the lithogenic distribution and atmospheric distribution. This model represents a leader in spatial interpretations of the deposition distribution model of normal and anomalous states.

Keywords: Metals distribution, ANN-MLP, Mining, Environmental distribution

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COMPOST RELIEVES METAL TOXICITY AND HEALTH RISKS AND ENDURES LETTUCE PLANTS IN METAL POLLUTED SOILS WITH DIFFERENT pH LEVELS

***Sana Ullah*[1]*, Karolina Barcauskaite[1]**

*[1]Lithuanian Research Centre for Agriculture and Forestry, Institute of Agriculture, Instituto Al. 1, LT-58344 Akademija, Kedainiai District, Lithuania, *sana.ullah@lammc.lt*

A pot experiment was designed to check the effect of compost soil characteristics and physiology and metal accumulation of lettuce planted in different pH soils receiving polluted irrigation of wastewater (WW). The experiment was designed following a factorial setup of sixteen treatments: 2 soils, 2 compost levels, 4 WW irrigations, each treatment with three replications. The results showed that Cu- and Zn-polluted WW significantly reduced the growth, chlorophylls, and carotenoid pigments of lettuce plants in both soils under NoCompost conditions. However, the decline in these attributes was more pronounced in acidic soil (45–59%) than in neutral soil (30–38%). In the case of neutral soil, Zn-polluted WW did not negatively affect these attributes compared to the control. All the metal-polluted treatments increased total polyphenols, polyphenolic acids, flavonoids, and antiradical activity in lettuce shoots. Alternatively, the compost application consistently increased (8–50%) the growth and physiological attributes of lettuce in both soils. Compost treatment decreased root and shoot metal (Cu, Zn) concentrations and uptake by 25–60% and 16–25%, respectively, in both soils. Likewise, compost decreased the metal health risk index (37%–2.7 folds) in both soils. Copper-polluted WW decreased the dehydrogenase activity of soils more than Zn-polluted WW, but compost significantly increased it in both soils, enhancing the organic matter contents of both soils. Conclusively, the addition of compost at the rate of 2% substantially alleviated the metal toxicity and, thereafter, human health risks in both soils.

Keywords: Wastewater, Copper, Zinc, Lettuce, Health risk

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