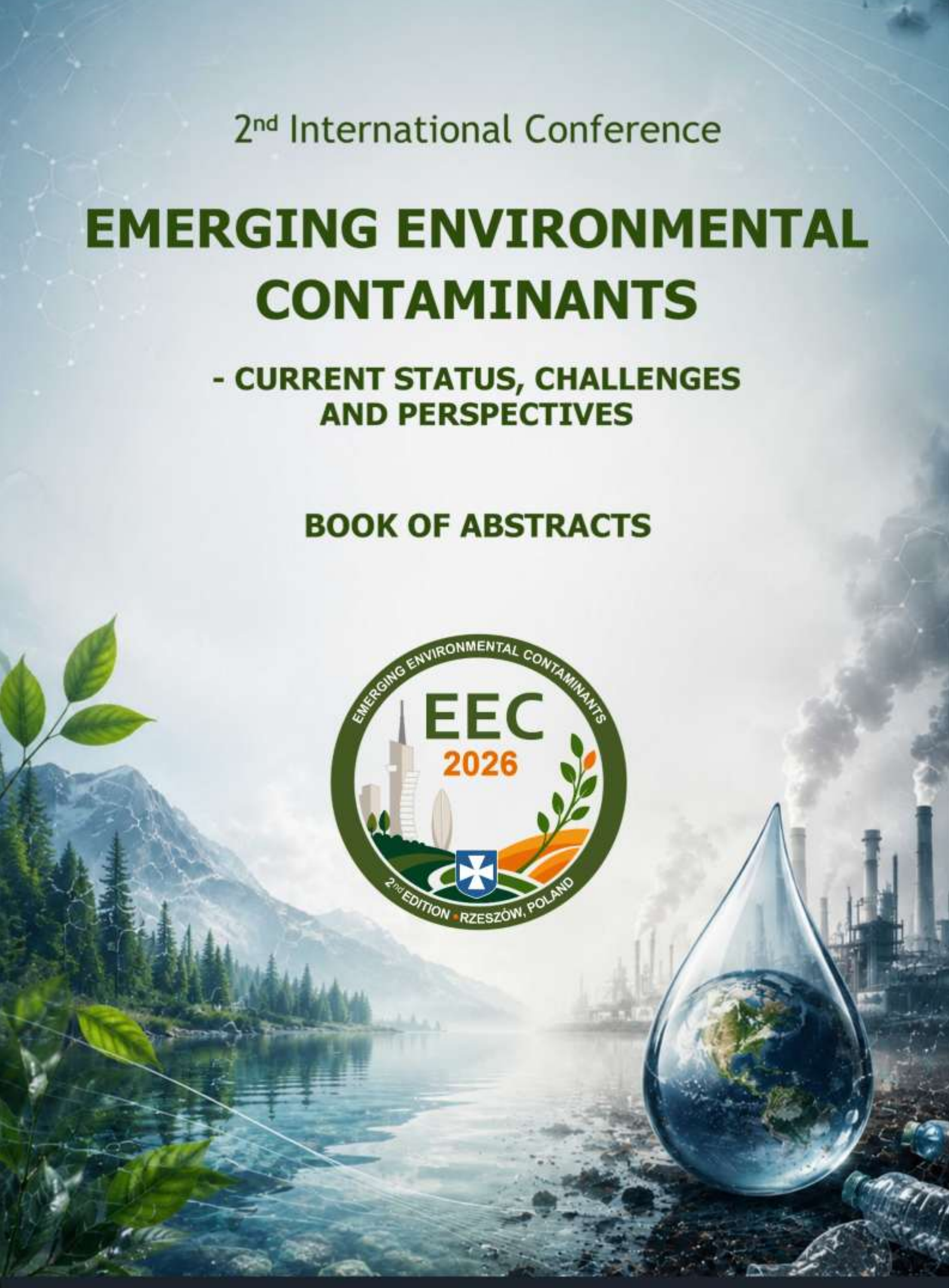
2nd International Conference

EMERGING ENVIRONMENTAL CONTAMINANTS

- CURRENT STATUS, CHALLENGES AND PERSPECTIVES

BOOK OF ABSTRACTS



Rzeszów-Poland, 9-11 September 2026

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University of Rzeszów

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University of Rzeszów
ul. Aleksandra Zelwerowicza 4
35-601 Rzeszów, Poland

University of Rzeszów

Dear Participants,

we are delighted to welcome you to the 2nd International Conference Emerging Environmental Contaminants – Current Status, Challenges and Perspectives (EEC 2026). Building on the success of the first edition and the strong interest shown by researchers and environmental professionals, we are pleased to continue this initiative as a platform for sharing knowledge, experience, and research findings related to contemporary environmental challenges and sustainable development.

This year's conference brings together researchers, experts, PhD students, and undergraduates from academic and research institutions across Europe, Asia, and Africa. The programme addresses key topics including soil, water, and air protection, environmental risk assessment, pollution monitoring, circular economy solutions, remediation technologies, and climate change impacts on ecosystems. Through plenary lectures, oral presentations, and poster sessions, participants will have the opportunity to explore recent advances in environmental science and engineering. The broad range of topics presented highlights the interdisciplinary nature of environmental research and creates opportunities for scientific exchange, collaboration, and the development of new research initiatives.

We are pleased to present this Book of Abstracts, which reflects current research trends, innovative methodologies, and the scientific community's commitment to addressing environmental challenges. We hope that this publication will be a valuable source of knowledge and inspiration for all participants.

We thank all participants for contributing to the success of this event and wish you fruitful discussions, inspiring meetings, and a rewarding conference experience.

Head of the RID Programme
Scientific Committee
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AGENDA

Program of the 2nd Conference Emerging Environmental Contaminants – Current Status, Challenges and Perspectives, 9-11 September, 2026, Rzeszów, Poland

Wednesday, 9th September 2026 – Day 1
University of Rzeszów, Zelwerowicza St. 4, 35-601 Rzeszów, Building D9, Conference Hall 108

9:00-10:00	**REGISTRATION**
10:00	**Opening and welcoming conference participants**
Opening Session 10:30-12:00	**CONFERENCE KEYNOTES**

SOILS: FROM WASTELANDS TO OPPORTUNITIES – Mark Maboeta

TESTING THE PERFORMANCE OF EUROPEAN DIATOM INDICES FOR EVALUATING THE ECOLOGICAL STATUS IN SOME RIVER BASINS IN TÜRKIYE: KIZILIRMAK AND SAKARYA BASIN CASES – Cüneyt Nadir Solak, Łukasz Peszek, Tolga Çetin, Paul B. Hamilton

FROM CARBON AGRICULTURE WITH SEAWEEDS TO BIOREMEDIATION WITH MICROALGAE – Kiril Bahcevandziev

12:00-12:30	**COFFEE BREAK**
PANEL A Hall 108 12:30-13:45	**SOIL, POLLUTION, REMEDIATION**

SELECTED EMERGING CONTAMINANTS - THEIR ECOTOXICITY AND IMPACT ON SOIL HEALTH – Agnieszka Klimkowicz-Pawlas, Monika Pecio, Anna Gałązka, Agnieszka Fiszka-Borzyszkowska, Lidia Wolska

PROBABILITY MAPPING OF METAL MOBILIZATION RISK IN COASTAL ACID SULFATE SOILS OF POLAND – Piotr Hulisz, Sylwia Pindral

TRDMT1 AS A CYTOTOXIC FACTOR INCREASING THE SENSITIVITY OF OSTEOSARCOMA CELLS TO CAMALEXIN, BRASSININ AND ACETAMIPRID – Viera Schwarzbacherová, Jagoda Adamczyk-Grochala, Maciej Wnuk

EMPLOYING PLANT-PARASITIC NEMATODES AS BIOLOGICAL INDICATORS OF SOIL CONTAMINATION AND ECOSYSTEM HEALTH – Anita Zapałowska

MICROBIAL DEGRADATION OF FUNGICIDES IN APPLE PRODUCTION: FROM LABORATORY STUDIES TO FIELD APPLICATIONS AND RISK ASSESSMENT – Magdalena Podbielska, Małgorzata Kus-Liśkiewicz, Ewa Szpyrka

13:45-14:45	**LUNCH BREAK**
PANEL A continuation 14:45-15:45	**SOIL, POLLUTION, REMEDIATION**

PAHS ASSESSMENT OF PAH CONTAMINATION IN SOILS NEAR THE FORMER GLIMAR OIL REFINERY (GORLICE, POLAND) USING GC-MS/MS – Kinga Wencel, Witold Żukowski, Igor Łabaj, Lizardo Reyna-Bowen

ECOTOXICOLOGICAL EVALUATION OF PESTICIDE ACTIVE INGREDIENTS AND FORMULATIONS USING *FOLSOMIA CANDIDA* – Isha Shakoor, Iwona Gruss, Irmina Ćwieląg-Piasecka, Cristina Menta

DOES LONG-TERM CEREAL MONOCULTURE NEGATIVELY AFFECT ORGANIC MATTER DECOMPOSITION? – Olena Niszczak, Jacek Twardowski, Roman Wacławowicz, Kamila Twardowska, Joanna Magiera-Dulewicz

ENVIRONMENTAL IMPACT OF LARGE FIRE OF CHEMICAL WASTE – A CASE STUDY FROM SIEMIANOWICE ŚLĄSKIE – Wojciech Rykała, Dominika Dąbrowska, Janusz Janeczek, Marek Sołtysiak, Ewa Łupikasza, Mariola Jabłońska, Monika J. Fabiańska, Tetiana Kalinichenko

PANEL B
Hall 131
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MONITORING WATER QUALITY, POLLUTION SOURCES AND MICROPLASTICS

INTEGRATED ASSESSMENT OF CANAL WATER QUALITY IN SEMI-ARID REGION OF INDIA: HYDROGEOCHEMISTRY, IRRIGATION SUITABILITY, HEAVY METAL DISTRIBUTION, AND PROBABILISTIC HUMAN HEALTH RISK EVALUATION – Poonam Mundlia, Kamlesh Kumar Sharma, Deepak Attri, Ruby, Dimple, Priyadarshi Meena, Sunil Chhimpa, Arup Giri

PLANT-BASED TOXICITY ASSESSMENT AND PAH REMOVAL IN TREATED LANDFILL LEACHATE – Aleksandra Wdowczyk, Wojciech Rykała, Dominika Dąbrowska, Agata Szymańska-Pulikowska, Monika Fabiańska

FROM ENVIRONMENTAL MONITORING TO TERRITORIAL PLANNING: FOZWASE AS A MUNICIPAL SCIENCE-BASED APPROACH TO ESTUARINE GOVERNANCE – Joana L. Rocha, Margarida Gouveia, Ana Fernandes, José Silva

BEYOND THE PEAK OF A TOXIC BLOOM: ACTINOCYCLUS SUBTILIS AS A POTENTIAL MARKER OF OSTREOPSIS DECLINE – Adrian Kryk, David G. Mann, Magda Vila, Sofía I. Homedes, Elisa Berdalet, Rosa Trobajo

SOURCE APPORTIONMENT OF SURFACE WATER POLLUTION IN A DELTAIC RIVER SYSTEM USING UNITED STATE ENVIRONMENTAL PROTECTION AGENCY (USEPA), POSITIVE MATRIX FACTORIZATION (PMF): THE CASE OF EDE ONYIMA CREEK, NIGER DELTA, NIGERIA – Emmanuel Francis, Essiene McLean Stanley

13:45-14:45 **LUNCH BREAK**

PANEL B continuation
Hall 131
14:45-15:45

MONITORING WATER QUALITY, POLLUTION SOURCES AND MICROPLASTICS

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THE ROLE OF PLANT BIOTECHNOLOGY IN THE SUSTAINABLE USE OF MEDICINAL PLANTS FOR ENVIRONMENTAL PROTECTION – Monika Tkalec Kojić

DETERMINANTS OF CIRCULAR ECONOMY IMPLEMENTATION IN WASTEWATER TREATMENT PLANTS – Paulina Marcinek, Magdalena Andrunik, Marzena Smol

DETERMINATION OF MICROPLASTICS IN HTC-PROCESSED AND UNTREATED SEWAGE SLUDGE USING A NOVEL SINGLE-VESSEL EXTRACTION METHOD – Wojciech Strojny, Renata Gruca-Rokosz, Zuzanna Prus, Małgorzata Wilk, Katarzyna Styszko

15:45-16:15 **COFFEE BREAK – time for discussion!**

Partners Session

Hall 108

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MicroBioTests – Wouter Lanneau

TIGRET SP. Z O.O – Grzegorz Piętowski, Justyna Chojnacka

PCI, Podkarpackie Centrum Innowacji Sp. z o.o. – Timea Sulenta-Pluta

Summary of the Day 1

Hall 108

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19:00-22:00 **DINNER**

Thursday, 10th September 2026 – Day 2

PANEL C

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URBAN ORGANIC RESOURCES IN THE TRANSITION TOWARDS A CIRCULAR BIOECONOMY – Ivan Tymchuk, Myroslav Malovanyy, Volodymyr Zhuk, Bohdan Romanovych

DRIVERS AND BARRIERS FOR SCALING ORGANIC SOIL IMPROVERS: A CROSS-REGIONAL SWOT ASSESSMENT – Edyta Waluś, Marzena Smol

THE IMPORTANCE OF LOCAL USE OF HEAT AND CO_2 FOR THE PROFITABILITY OF AGRICULTURAL BIOGAS PLANTS ON DAIRY FARMS – Jakub Mazurkiewicz, Monika Suchowska-Kisielewicz

ORGANIC-BASED PENETRATING AGENTS AS ADJUVANTS: A BOOST TO AGRICULTURAL EFFICACY OR A PHYTOPHYSIOLOGICAL LIMITATION? – Ewa Szwajczak, Katarzyna Larysz, Michał Ludynia, Edyta Sierka

BIOREMEDIATION POTENTIAL OF WOOD-DECAY FUNGI ON CONTAMINATED RECYCLED WOOD: TOWARDS UPCYCLED MYCELIUM-BASED THERMAL INSULATION MATERIALS FOR CIRCULAR CONSTRUCTION – Benjamín Petržela, Miroslav Jozífek, Štěpán Hýsek

PANEL D

Hall 131 **TOXICITY OF PFAS, PHARMACEUTICALS AND EMERGING CONTAMINANTS AND TECHNOLOGIES FOR THEIR ELIMINATION**

10:00-11:30

TURNING LOW-QUALITY CLAY MINERALS INTO HIGH-VALUE CATALYSTS: PHOTOCHEMICAL ELIMINATION OF EMERGING POLLUTANTS USING FE-BEARING MINERAL WASTE – Agnieszka Węgrzyn, Xuan Tien Dao, Paweł Miśkowiec

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WHEN WARMTH AMPLIFIES THE CHEMICAL THREAT: HOW MODERN PFAS (GENX) AND THERMAL STRESS CO-CONSPIRE TO DISMANTLE MARINE HOST DEFENSES AND TISSUE INTEGRITY – Davide Di Paola

FROM BIOACCUMULATION TO PHYSIOLOGICAL STRESS: SALINITY-DEPENDENT EFFECTS OF IONIC LIQUIDS IN MYTILUS TROSSULUS – Joanna Dołżonek, Lilianna Sharma, Anna Pouch, Adriana Mika, Klaudia Godlewska, Montserrat Solé, Grzegorz Siedlewicz, Anna Białk-Bielińska, Ksenia Pazdro

SELECTION OF PARAMETERS FOR THE ELECTROCHEMICAL OXIDATION OF PARACETAMOL USING A BDD ELECTRODE FLOW CELL – Julia K. Nowak, Paweł Lochyński, Paweł Jajor, Błażej Późniak, Andrew Taylor, Piotr Jedziniak

DECISION-SUPPORT APPROACH FOR WATER REUSE: WATERSAFE TOOL APPLICATION IN FINNISH WWTP – Dominika Szołdrowska, Monika Wojciechowska, Klara Ramm, Marzena Smol

11:30	**TAKE YOUR COFFE AND GO TO… ↓↓↓**
11:30-12:15	**POSTER SESSION**
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ULTRAFINE AND FINE AIRBORNE PARTICLES DURING A SAHARAN DUST INTRUSION: SIZE DISTRIBUTION AND FREE RADICAL CONTENT – Julia Brewka, Katarzyna Kluska, Idalia Kasprzyk, Bogumił Cieniek, Dariusz Płoch, Ireneusz Stefaniuk

CYTOTOXICITY OF WATER-AND ORGANIC-SOLUBLE TAR AEROSOLS GENERATED BY PYROLYSIS OF WOOD – Nadira Zendi, Vinh Nguyen, Bartłomiej Witkowski, Małgorzata Milczarek, Tomasz Gierczak

KINETIC MEASUREMENTS AND ATMOSPHERIC LIFETIMES OF SUGAR ACIDS – Vinh Nguyen, Yimu Zhang, Thomas Schaefer, Bartłomiej Witkowski, Tomasz Gierczak, Hartmut Herrmann

PLANT IDENTITY SHAPES SOIL CORE MICROBIOMES OF POST-INDUSTRIAL SITES – Katarzyna Larysz, Ewa Szwajczak, Michał Ludynia, Edyta Sierka

14:00	Conference Summary
14:15	**LUNCH**
15:00-18:00	**WORKSHOPS**

Hands-On Training in Environmental Toxicity Assessment (Zelwerowicza St. 4, Building D9 – 16)
Turbidity Measurement (Zelwerowicza St. 4, D9 – 222)
Algae Isolation and Cultivation (Ćwiklińskiej St. 1A, D3 – 222)

Advanced Applications of ICP-MS (Rejtana St. 16c. Building A0/B4 – 106)

Friday, 11 September 2026 – Day 3

9:00-17:00	**Trip** - Museum of Oil and Gas Industry Ignacy Łukasiewicz in Bóbrka (including dinner)

POSTER SESSION

ASSESSMENT OF AQUATIC SEDIMENT CONTAMINATION OF RESERVOIRS IN URBANISED AND INDUSTRIALISED REGIONS WITH RESPECT TO METALS IN THE CONTEXT OF CLIMATE CHANGE – Urszula Aleksander-Kwaterczak, Maria Bukowska, Hanna Michno

DETERMINATION OF THE CHEMICAL COMPOSITION OF FILTERS USED FOR TAP WATER FILTRATION – Urszula Aleksander-Kwaterczak, Katarzyna Wątor, Jagoda Swoboda, Piotr Rusiniak

OZONATION AS A GREEN PERSPECTIVE FOR MYCOTOXIN DEGRADATION IN PLANT RAW MATERIALS: EFFICIENCY AND BY-PRODUCTS PROFILE – Maciej Balawejder, Radosław Józefczyk, Piotr Antos

DETERMINATION OF THE LEVELS OF HEAVY METALS IN T-SHIRTS AND ASSESSING DERMAL EXPOSURE RISKS – Agnieszka Baran, Jerzy Wieczorek, Julia Jaworska, Julia Tubek

AGRICULTURAL WASTE BIOCHAR AS A LOW-COST ADSORBENT FOR PHARMACEUTICAL AND ANTIBIOTIC REMOVAL FROM CONTAMINATED WATER – Sydney S. Blankson, Lyndon N.A. Sackey, Jones O. Twumesi, Bernard Fei-Baffoe

SUSTAINABLE DAIRY LOGISTICS AND ENVIRONMENTAL FOOTPRINT REDUCTION IN SHORT FOOD SUPPLY CHAINS – Martyna Bluj, Agnieszka Podolak, Małgorzata Ormian, Jadwiga Topczewska

TREATMENT OF CONTAMINATED AQUATIC ENVIRONMENTS USING MAGNETICALLY RESPONSIVE BIOCHAR ADSORBENTS – Ihor Bordun, Myroslav Malovanyy, Nazar Nahurskyi

FRESH VERSUS CANNED FISH AND SEAFOOD AS DIETARY SOURCES OF 210PO AND 210PB – Alicja Boryło, Klaudia Lanczewska-Bejenka, Paweł Rudnicki-Velasquez

TRANSFORMATION OF MUNICIPAL SEWAGE SLUDGE INTO ENVIRONMENTALLY SAFER ORGANIC-MINERAL FERTILIZERS: CHALLENGES AND PERSPECTIVES – Joanna Czarnota, Adam Masłoń, Justyna Koc-Jurczyk, Dagmara Migut, Agnieszka Podolak

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INTEGRATING SOIL REMEDIATION AND WATER TREATMENT: PHOTOCATALYTIC REUSE OF ORGANIC ACID-TREATED CLAY MINERALS FOR EMERGING POLLUTANT REMOVAL – Xuan Tien Dao, Paweł Miśkowiec, Agnieszka Węgrzyn

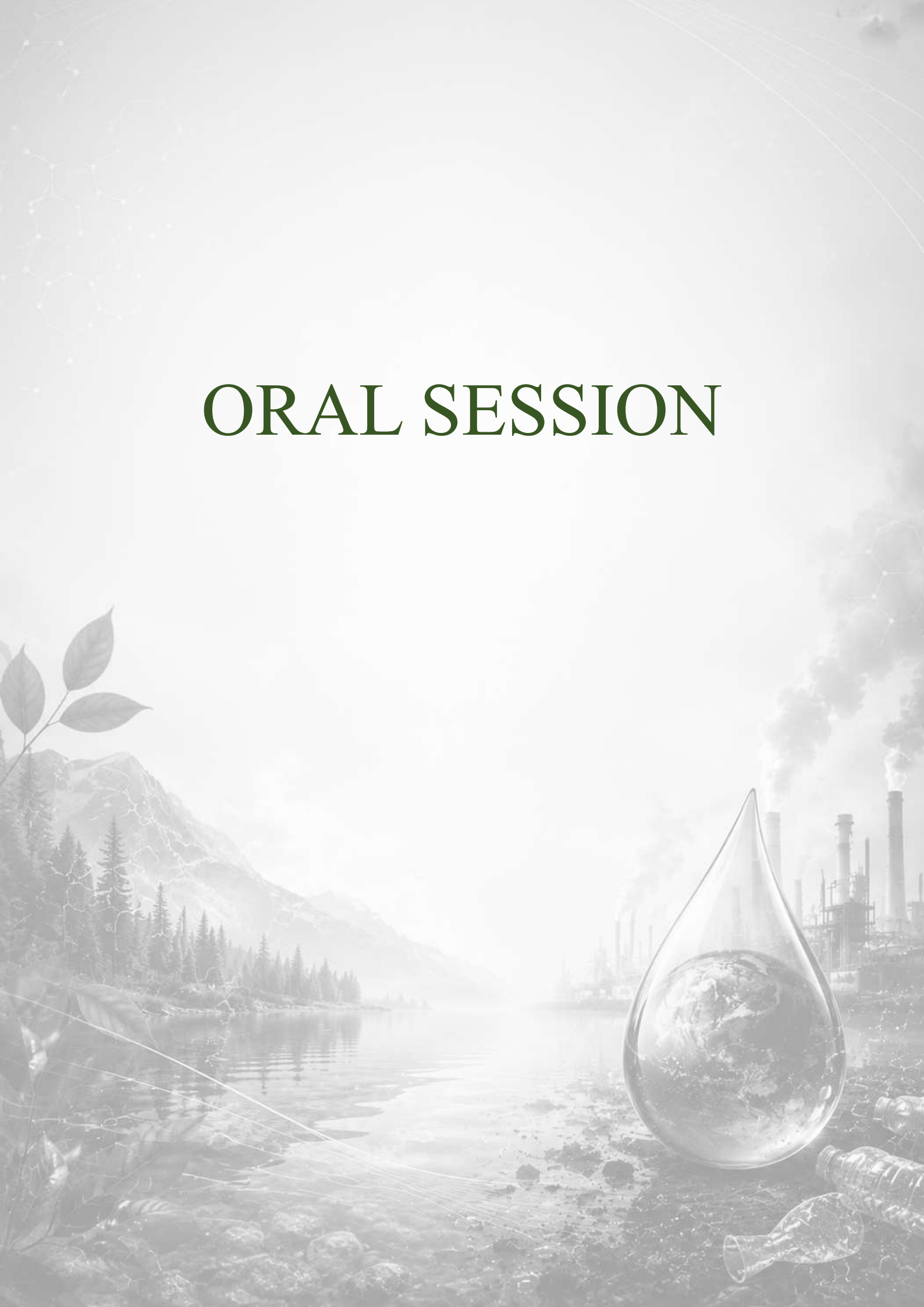
FROM WILD HARVESTING TO CULTIVATION: INTRODUCTION OF ARNICA MONTANA L. AS A PREREQUISITE FOR CONTROLLED PRODUCTION OF MEDICINAL RAW MATERIAL – Andrii Dubliak, Nadiia Riznychuk

BIODIVERSITY OF MICROBIOME AND MYCOBIOME OF LONG-TERM OIL-CONTAMINATED SOILS – Anna Gałązka, Katarzyna Wiejak, Jarosław Ciepiel, Karolina Gawryjołek, Aleksandra Ukalska-Jaruga, Anna Marzec-Grządziel

COMPARATIVE ANALYSIS OF POLYCYCLIC AROMATIC HYDROCARBON (PAHs) CONTENT IN SOILS FROM CITY PARKS IN RZESZÓW AND KRAKÓW USING THE GC-MS/MS TECHNIQUE – Amelia Gargała, Roksana Szkoła, Agnieszka Gruchot, Zuzanna Hanus, Magdalena Słowik-Borowiec

MUNICIPAL PARKS AS EARLY WARNING SYSTEMS FOR SOIL CONTAMINATION – INSIGHTS FROM RZESZÓW'S RECREATIONAL AREAS – Anna Górka, Maria Sanecka

ORAL SESSION



FROM CARBON AGRICULTURE WITH SEAWEEDS TO BIOREMEDIATION WITH MICROALGAE

Kiril Bahcevandziev[1,2]

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In the past we were teaching/learning/discussing the conventual and/or extensive agriculture, maybe some notes about sustainable agriculture and today we use “more sophisticated” soilless agriculture, or hydroponics or even today low-carbon and regenerative agriculture. Algae are emerging not merely as passive nature-based engineered bioplatforms, but as dynamic bio-circular platforms capable of simultaneously be biostimulants and biofertilizers and removing contaminant mixtures while generating vaporizable biomass within integrated water-resource systems. Freshwater and marine micro- and macroalgae possess diverse physiological and biochemical traits that enable them to assimilate excess nitrogen and phosphorus, absorb and accumulate metals, bind organic pollutants, and immobilize emerging contaminants such as pharmaceuticals, hydrocarbons, and microplastics. To define why carbon is so important for agriculture, how we can use it or how we can “get rid of it” and mainly how we can earn money with it. There are different ways to remove the pollution from the water. There are different micro- and macro algae that are “doing that job” mainly in their home water habitat. There are explained different ways of using macroalgae in agriculture and how algae, in general, are used in “cleaning” the polluted water environments. Filamentous green algae such as *Cladophora glomerata*, *Cladophora rivularis*, *Ulothrix zonata*, *Oedogonium intermedium*, *Oedogonium capillare*, and *Rhizoclonium hieroglyphicum* are studied in removing the heavy metals and pollutants from the fresh water and *Fucus vesiculosus*, *Fucus serratus*, *Ascophyllum nodo*sum, *Laminaria digitata* and *F. vesiculosus* from the sea water. We have already produced seaweeds as biostimulant and there are preliminary studies that show the algae importance in “cleaning” the water environment.

Keywords: agriculture, sarbon, seaweeds, microalgae, ficoremediation.

ULTRAFINE AND FINE AIRBORNE PARTICLES DURING A SAHARAN DUST INTRUSION: SIZE DISTRIBUTION AND FREE RADICAL CONTENT

Julia Brewka[1], Katarzyna Kluska[1], Idalia Kasprzyk[1], Bogumił Cieniek[2], Dariusz Płoch[2], Ireneusz Stefaniuk[2]

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The aim of this study was to investigate the oxidative properties of airborne particulate matter (PM) collected during the heating season (February–March) and the non-heating season (September) over a two-year period, with particular emphasis on the spring 2025 Saharan dust intrusion that reached southeastern Poland. Special attention was paid to the smallest PM fractions, as their ability to penetrate deep into the respiratory system may enhance their biological activity and potential adverse effects on human health. Particulate matter was separated into fifteen size fractions (6 nm–10 μm), including ultrafine particles, which remain poorly characterized during Saharan dust episodes in this region. Electron paramagnetic resonance (EPR) spectroscopy was used to identify and quantify free radicals associated with individual PM fractions as markers of oxidative potential. The results demonstrated that ultrafine particles (<1 μm) exhibited a substantial contribution to the overall free radical content. During the Saharan dust episode, these fine and ultrafine fractions showed altered oxidative properties, indicating an increased potential to induce oxidative stress. Because oxidative stress is one of the key mechanisms underlying particle-induced toxicity, these findings suggest that Saharan dust intrusions may modify the biological reactivity of inhaled aerosols and consequently influence the health risks associated with exposure, particularly for the respirable and ultrafine PM fractions. This study provides new insights into the potential biological implications of long-range dust transport, highlighting the importance of assessing oxidative potential across different particle size fractions to better understand the health effects of episodic Saharan dust events.

[1]. Cieniek, B.; Płoch, D.; Brewka, J.; Kluska, K.; Stefaniuk, I.; Kasprzyk, I. Chemical Composition and Free Radical Content During Saharan Dust Episode in SE Poland. Molecules 2025, 30, 4799

Keywords: free radicals, Saharan dust, EPR, particulate matter, air pollution.

This research was supported by the Minister of Science of the Republic of Poland under the Programme „Regional initiative of excellence". Agreement No. RID/SP/0010/2024/1.

WHEN WARMTH AMPLIFIES THE CHEMICAL THREAT: HOW MODERN PFAS (GENX) AND THERMAL STRESS CO-CONSPIRE TO DISMANTLE MARINE HOST DEFENSES AND TISSUE INTEGRITY

Davide Di Paola

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The ecotoxicological footprint of modern fluorinated alternatives like GenX remains poorly understood, especially when interacting with ocean warming. This study uncovers the physiological and molecular consequences of co-exposure to GenX and thermal stress (+5°C) in a key sentinel bivalve.Organisms were exposed for 14 days to four distinct treatment regimes: Control (18°C), Warming (23°C), GenX (10 µg/L at 18°C), and Combined Stress (GenX at 23°C). We quantified immunocyte dynamics, multi-organ histopathology, antioxidant gene expression (SOD, CAT, GPx, GST), apoptosis (p53), and neurotoxicity markers (AChE, CbEs).Co-exposure triggered a catastrophic physiological breakdown. While single stressors (warming or GenX alone at 18°C) activated protective pathways, their combination led to a complete collapse of the antioxidant system, with SOD, CAT, GPx, and GST expression dropping significantly below baseline levels. This metabolic exhaustion coincided with profound immunodepression—evidenced by a drastic loss of circulating granulocytes ($p<0.0001$)—alongside extensive gill disorganization, epithelial erosion, and digestive gland atrophy. Severe neurotoxicity (AChE/CbEs inhibition) and cell death (p53 upregulation) further marked this systemic failure

FROM BIOACCUMULATION TO PHYSIOLOGICAL STRESS: SALINITY-DEPENDENT EFFECTS OF IONIC LIQUIDS IN *MYTILUS TROSSULUS*

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Ionic liquids (ILs) are emerging contaminants with increasing environmental relevance. Although their bioaccumulation has been demonstrated, little is known about the biochemical mechanisms underlying their toxicity in marine organisms or the influence of salinity on these responses. This study investigated the effects of 1-decyl-3-methylimidazolium chloride ([IM1–10]Cl) on the Baltic mussel *Mytilus trossulus* under two environmentally relevant salinity conditions. Mussels were exposed to 10 μg L^{-1} [IM1–10]Cl at 8 and 16 PSU for 21 days, followed by a 21-day depuration period. Tissue concentrations of the ionic liquid were determined using LC-MS/MS, while biochemical responses were evaluated by measuring biomarkers of antioxidant defense, detoxification, neurotoxicity, and lipid metabolism, including fatty acid composition and the activities of stearoyl-CoA desaturase-1 (SCD1) and elongases (ELOVL1 and ELOVL6). [IM1–10]Cl accumulated in mussel tissues, with significantly higher concentrations at 16 PSU. Exposure altered catalase, glutathione S-transferase, and carboxylesterase activities, indicating oxidative stress and impaired detoxification. These biochemical disturbances persisted after the depuration period. Lipid metabolism was also affected, as reflected by changes in fatty acid composition and the activities of ELOVL1, ELOVL6, and SCD1. Among the investigated biomarkers, SCD1 showed the earliest and most persistent response, highlighting its potential as an early-warning biomarker of IL exposure. Overall, exposure to [IM1–10]Cl induced persistent physiological disturbances that extended beyond bioaccumulation. Salinity modulated both contaminant uptake and biochemical responses, emphasizing the importance of considering environmental conditions when assessing the ecological risks of ionic liquids.

Keywords: ionic liquids; *Mytilus trossulus*; biomarkers; lipid metabolism; salinity

SOURCE APPORTIONMENT OF SURFACE WATER POLLUTION IN A DELTAIC RIVER SYSTEM USING UNITED STATE ENVIRONMENTAL PROTECTION AGENCY (USEPA), POSITIVE MATRIX FACTORIZATION (PMF): THE CASE OF EDE ONYIMA CREEK, NIGER DELTA, NIGERIA

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Accurate identification of pollution sources is essential for designing effective remediation strategies. This study applied the USEPA Positive Matrix Factorization (PMF 5.0) receptor model to apportion sources of potentially toxic elements (PTEs) and hydrocarbon-related contaminants in the surface waters of Ede Onyima Creek, Niger Delta, Nigeria. Water quality datasets were analysed to resolve statistically stable and environmentally interpretable source profiles. Model performance was evaluated using coefficients of determination (r^2 = 0.59–0.99), bootstrap (BS), and displacement (DISP) diagnostics. PMF resolved two dominant sources in surface water: (1) a petrogenic factor characterized by Fe (90.5%), total petroleum hydrocarbons (TPH, 81.0%), total hydrocarbon content (THC, 80.2%), and Mn (60.6%), consistent with crude oil releases, produced water discharges, and oil infrastructure activities; and (2) a diffuse anthropogenic factor dominated by polycyclic aromatic hydrocarbons (PAH, 100%), pH (98.8%), *Escherichia coli* (86.0%), turbidity (83.7%), and dissolved oxygen (83.5%), reflecting combustion-derived PAH deposition and stormwater runoff processes. Diffuse sources accounted for approximately 86% of overall water contamination, with pyrogenic PAH emerging as the primary pollutant signature. The integration of hydrocarbon markers (TPH, THC, PAH) with metals (Fe, Mn) demonstrates that surface water contamination in Ede Onyima Creek is structured along dual anthropogenic axes: oil extraction–related petrogenic inputs and combustion/runoff-driven diffuse inputs. These findings indicate that the creek's assimilative capacity may be under increasing pressure and underscore the need for targeted regulatory interventions addressing artisanal refining emissions, produced water management, and nonpoint runoff control. This study provides a transferable PMF-based framework for source identification in hydrocarbon-impacted river systems across the Global South.

Keywords: Deltaic River System, USEPA PMF 5.0, Surface water pollution, Ede Oyima Creek

PROBABILITY MAPPING OF METAL MOBILIZATION RISK IN COASTAL ACID SULFATE SOILS OF POLAND

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Coastal acid sulfate soils contain sulfide-bearing materials that may generate strong acidity when exposed to oxygen due to drainage, excavation, drought, or prolonged groundwater lowering. Acidification (often with pH < 4) can substantially increase the mobility of metals, including Al, As, Cd, Cr, Mn, Ni, Pb, and Zn, thereby posing a risk to adjacent terrestrial and aquatic ecosystems. This issue is particularly important in protected coastal wetlands, where hydrological disturbances may affect valuable habitats and biodiversity. The study aimed to identify areas with a high probability of acid sulfate (AS) soil occurrence along the north-western Polish coast and to assess their relevance to the spatially distributed risk of toxic metal mobilization. Such an analysis has not been conducted so far. To evaluate the probability maps, we applied a digital soil mapping approach based on the Random Forest algorithm. The dataset comprised 204 sampling points compiled from three sources: the author's study, published literature, and soil-agricultural maps. It included 72 field-validated AS soil sites and 132 sites classified as non-AS soils. As explanatory variables, selected topographic, soil, geological, and spectral indicators were derived from a 1-m digital elevation model, a soil-agricultural map, a detailed geological map, and five-year averages of Sentinel-2 imagery. Variance inflation factor (VIF) analysis was applied to select the final set of 35 covariates. The model demonstrated high predictive performance, with an R^2 of 0.96 and an RMSE of 0.11. The maps revealed that zones with a high probability of AS soil occurrence (75–100%), covering approximately 1900 ha (6.6%), were concentrated mainly in the low-lying wetlands within the islands of the Świna reverse delta, around Lake Wicko Wielkie and Krzecki Zalew. Smaller high-probability zones occurred along the shores of Lake Koprowo, Kamień Lagoon, and the Dziwna Strait. Many of these areas are located within or close to Wolin National Park and Natura 2000 sites. A previous study by the authors showed that metal concentrations in soils generally did not exceed applicable regulatory thresholds. However, widespread sulfide oxidation could generate substantial diffuse metal loads transported by surface runoff and shallow groundwater.
The AS soils probability maps may support identification of priority areas for field verification, hydrological protection, and geochemical monitoring. Maintaining stable groundwater levels and avoiding drainage or deep excavation are essential to prevent severe soil acidification and metal release in protected coastal ecosystems.

Keywords: acid sulfate soils; metal mobilization; probability mapping; protected areas; Wolin Island

SELECTED EMERGING CONTAMINANTS - THEIR ECOTOXICITY AND IMPACT ON SOIL HEALTH

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Soil is a fundamental and non-renewable natural resource that provides goods and services essential to ecosystems and human life, and forms the basis of food production and food security. Soil health can be threatened by numerous pollutants, including emerging compounds such as pesticides, hormones, antibiotics and antibiotic resistance genes. In recent years, increasing concern has been directed towards the potential release of such substances as a result of intensive livestock farming. Pharmaceuticals may negatively affect soil functions, and contribute to the loss of supporting (e.g., nutrient transformation), regulating (e.g., climate regulation), or provisioning (e.g., genetic resources) ecosystem services.

Research was therefore carried out to assess the impact of pharmaceutical residues from intensive poultry farming on soil health, biological activity and ecotoxicity.

Soil samples were collected from the top layer of two arable fields (fertilized and non-fertilized with manure) in early spring and autumn 2021 and analysed for physicochemical properties (soil organic carbon, pH, available nutrients). Microbial indicators included enzymatic activity, microbial biomass, nitrification potential and metabolic profile, whilst the pollutants analysed covered trace elements and antibiotics. Soil ecotoxicity was assessed using *Aliivibrio fischeri*, *Thamnocephalus platyurus*, *Heterocypris incongruens* and *Sinapis alba* as test species.

A significant decline in soil biological activity was observed at the location closest to the improperly stored manure pile, where high concentrations of biogens and pharmaceutical residues were found. Soil ecotoxicity was also highest at this site, and the response of the organisms was as follows: *H. incongruens* (100% mortality) > *T. platyurus* (22% inhibition of feeding) > *A. fischeri* (11% inhibition of bioluminescence) > *S. alba* (9% stimulation of root growth).

Research has confirmed that emerging pollutants released from intensive livestock production may pose a risk to soil health; it is therefore important to monitor their residues and ecotoxicological effects.

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BEYOND THE PEAK OF A TOXIC BLOOM: ACTINOCYCLUS SUBTILIS AS A POTENTIAL MARKER OF OSTREOPSIS DECLINE

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Harmful algal blooms (HAB) are an important environmental challenge in coastal waters because they can affect ecosystem functioning, public health, beach use, and local coastal management. In the Mediterranean Sea, recurrent blooms of the benthic dinoflagellate *Ostreopsis* have been associated with respiratory symptoms in exposed coastal users. Monitoring usually focuses on the abundance of the harmful species, but bloom development and decline occur within broader microscopic communities growing on macroalgae and other shallow-water substrates. These accompanying communities may contain useful biological signals that can support the interpretation of bloom dynamics. This study aimed to assess whether the large centric diatom *Actinocyclus subtilis* could serve as a potential biological marker of the late or declining phase of potentially harmful *Ostreopsis* blooms. A two-year field study was conducted at Sant Andreu de Llavaneres, NW Mediterranean Sea. Epiphytic microalgal communities growing on macroalgae were collected during monthly surveys, with increased sampling frequency during the typical *Ostreopsis* bloom season. *Ostreopsis* abundance was monitored together with the accompanying benthic diatom assemblages. Diatom material was cleaned, examined using light and scanning electron microscopy, and used to calculate the relative abundance of *Actinocyclus subtilis* from diatom counts. *A. subtilis* was absent or rare during winter, spring, and early summer, but increased markedly from midsummer to autumn, reaching up to 12% of the counted diatom assemblage. In both seasonal cycles, its highest relative abundances were recorded around and, most clearly, after the seasonal maximum of *Ostreopsis*, when the bloom was entering its declining phase. Live observations further showed a shift from *Ostreopsis*-dominated mucilaginous assemblages to communities in which *A. subtilis* became frequent or locally dominant. The occurrence of *Actinocyclus* after *Ostreopsis* bloom maxima may indicate a recurrent biological signal of the late, declining phase of harmful blooms. Rather than serving as a direct proxy for toxicity, this diatom may help identify the ecological transition from bloom dominance to bloom decay. This case study shows that accompanying microalgal communities, when supported by reliable taxonomic identification, can provide valuable information beyond counts of the harmful species alone.

Keywords: HAB, bloom decline, epiphytic assemblages, centric diatoms, bloom dynamics

SOILS: FROM WASTELANDS TO OPPORTUNITIES

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Soils are among Earth's most vital yet most neglected resources. They sustain food production, filter water, cycle nutrients, and support extraordinary biodiversity yet they remain poorly understood, particularly in Africa. Anthropogenic pressures, most acutely mining and industrial processing, have reduced large areas of South African soil to ecological wastelands: contaminated, compacted, and biologically depleted, often near vulnerable communities.

This presentation traces a research trajectory spanning more than two decades, in which earthworm bioassays have been applied as sensitive, ecologically relevant tools for assessing soil degradation and informing environmental risk assessment. Using OECD-standardised (*Eisenia andrei*) and endemic (*Microchaetus* spp.) species as bioindicators, our group has investigated the sub-lethal and population-level effects of metals, fungicides, and other contaminants across agricultural, mining, and industrial landscapes. These bioassays have also been used to evaluate South Africa's legislated soil quality targets, revealing important disconnects between regulatory thresholds and ecological reality.

The "wastelands" framing, however, is only half the story. Degraded South African soils represent rich opportunities for ecotoxicological science, for informing policy and industry practice, and for rehabilitation research. The same soils that bear witness to decades of neglect can, with appropriate science-policy engagement, become case studies in recovery.

This talk argues that closing the gap between soil science and environmental governance is both urgent and achievable, and that bioindicator-based approaches offer a practical, evidence-based pathway to get there.

Keywords: soil ecotoxicology, earthworm bioassays, metal contamination, environmental risk assessment, soil quality legislation

LIFE CYCLE ASSESSMENT IN SUPPORT OF ENVIRONMENTAL MANAGEMENT: THE IMPACT OF ALLOCATION METHODS ON THE ENVIRONMENTAL PERFORMANCE OF CIRCULAR PRODUCTION SYSTEMS

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Life cycle assessment is widely applied to evaluate the environmental performance of circular manufacturing systems and waste management strategies. However, methodological choices regarding end-of-life allocation, particularly the cut-off and substitution approaches, can substantially influence the interpretation of circularity and decarbonization potential.
This presentation examines how different EoL allocation approaches influence the environmental assessment of plastic injection moulding systems and waste management pathways, with a particular focus on circular manufacturing and resource efficiency.
A cradle-to-grave LCA was conducted using primary industrial data from a high-density polyethylene injection moulding process. Three manufacturing scenarios representing open-loop, semi-closed-loop, and fully closed-loop systems were evaluated. Environmental impacts were assessed using the CML 2016 method, and carbon footprints for landfilling, incineration, and incineration with energy recovery were analysed using four LCIA methods (IPCC AR6, CML 2016, EF 3.1, and ReCiPe 2016). The influence of cut-off and substitution allocation approaches on the interpretation of circular economy performance was systematically compared.
The fully closed-loop scenario delivered the best environmental performance, reducing cumulative material consumption by 3.2% and freshwater emissions by 2.8% per functional unit, while cutting human and marine ecotoxicity by more than 85% through simultaneous water and material recirculation. The allocation methodology substantially influenced the perceived benefits of recycling and energy recovery. Although landfilling had the lowest direct carbon footprint, incineration with energy recovery significantly reduced net greenhouse gas emissions by avoiding energy production, with thermal recovery providing greater climate benefits than electricity generation. Consistent trends were observed across all LCIA methods. The results demonstrate that methodological choices are as important as technological improvements in shaping the environmental performance of circular manufacturing systems. Transparent allocation procedures are therefore essential for reliable LCA-based decision-making and for supporting the implementation of the circular economy and long-term decarbonisation strategies.

Keywords: Life Cycle Assessment, circular economy, injection moulding, end-of-life allocation, decarbonization

DETERMINANTS OF CIRCULAR ECONOMY IMPLEMENTATION IN WASTEWATER TREATMENT PLANTS

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Wastewater treatment plants (WWTPs) are increasingly evolving from conventional facilities into resource recovery systems that contribute to the Circular Economy (CE) through water reuse, nutrient recovery, renewable energy and the production of value-added products. Despite significant technological progress, the implementation of CE solutions remains uneven, indicating that non-technological factors play an equally important role in enabling circular transformation. This study aims to identify and evaluate the key determinants influencing CE implementation in WWTPs, with particular emphasis on technological, environmental, economic, social, organisational and regulatory factors. The study combines a comprehensive literature review with strategic analytical tools, including SWOT and PESTEL analyses, to systematically identify internal and external factors affecting CE implementation in WWTPs. The analyses are based on scientific literature, policy documents and current developments related to circular water management and resource recovery. The preliminary findings indicate that successful CE implementation depends on the interaction of multiple determinants rather than technological readiness alone. Regulatory support, environmental policies, stakeholder cooperation, technological innovation and access to financial resources were identified as major drivers of circular transition. Conversely, high investment and operational costs, regulatory complexity, organisational resistance, insufficient technical knowledge and limited stakeholder awareness remain significant barriers. The analyses also highlight increasing opportunities associated with the European Green Deal, stricter resource efficiency policies and growing demand for recovered resources, while market uncertainty and changing legislation continue to represent important external risks.

The findings demonstrate that the transition towards circular wastewater treatment requires an integrated approach addressing technological and non-technological determinants simultaneously. Understanding these interactions can support decision makers, water utilities and policymakers in developing effective strategies that accelerate CE implementation and improve the sustainable performance of WWTPs.

Keywords: Circular Economy, wastewater treatment plant, SWOT analysis, PESTEL analysis, resource recovery

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THE IMPORTANCE OF LOCAL USE OF HEAT AND CO_2 FOR THE PROFITABILITY OF AGRICULTURAL BIOGAS PLANTS ON DAIRY FARMS

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Agricultural biogas plants integrated with dairy farms are increasingly considered important components of circular bioeconomy systems and a significant contributor to reducing negative environmental impact. However, in many installations, the economic potential of waste heat and CO_2 generated in cogeneration processes remains insufficiently utilized. The aim of this study was to assess the impact of local heat and CO_2 utilization on the economic and environmental performance of agricultural biogas plants operating within dairy farm systems. Scenario-based simulations were conducted using research results from the international project "Multi-criteria assessment, decision support, and management tools for sustainable circular mixed farming systems for dairy production," developed for energy and economic modeling of biogas plants. Various dairy farm scenarios were analyzed, varying in scale and farm management characteristics. The model included electricity generation, heat recovery, CO_2 utilization in greenhouse production, and digestate valorization. Circular economy scenarios demonstrated significantly higher annual net profit despite increased investment costs and, at the same time, significantly greater impact on greenhouse gas emission reduction. The greatest economic benefits were associated with the use of waste heat for greenhouse heating and biomass drying, as well as with CO_2 valorization in greenhouse tomato cultivation. Additional benefits included reduced expenditures on mineral fertilizers, straw, and external energy sources. The results indicate that the profitability of agricultural biogas plants depends not only on electricity production but also on the effective local use of heat, CO_2, and digestates. Integrated circular economy solutions can significantly improve the economic resilience and resource efficiency of dairy farms.

Keywords: agricultural biogas plant, dairy farm, circular bioeconomy, waste heat utilization, CO_2 valorisation

AEROBIOLOGICAL MONITORING FOR THE DEVELOPMENT OF A REGIONAL POLLEN CALENDAR IN IVANO-FRANKIVSK (WESTERN UKRAINE)

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Airborne pollen from a wide range of anemophilous plants is a major trigger of seasonal allergic diseases, and climate-driven shifts in flowering phenology are altering pollination periods and airborne pollen dynamics for many allergenic taxa across Europe (Brake et al., 2023; Grewling et al., 2023; Beggs et al., 2023). In Ukraine, aerobiological observation remains fragmentary and is not yet embedded in the national air-quality monitoring system, leaving allergological forecasting without a reliable, locally calibrated evidence base. Building such a base ultimately requires a systematic, multi-species pollen calendar rather than isolated single-taxon records.

To pilot an aerobiological monitoring approach using early-spring allergenic taxa in Ivano-Frankivsk (Western Ukraine) as a pilot case study, and to outline how the resulting taxon-specific parameters can be scaled into a comprehensive regional pollen calendar covering the full local allergenic flora.

Daily airborne pollen concentrations of *Corylus avellana* and *Alnus* sp. were recorded using a Durham gravimetric sampler over a continuous 64-day period (23 February–27 April 2026). Season onset, peak, core-season duration (5th–95th percentile), and seasonal pollen index (SPI) were derived for each taxon and related to concurrent and lagged (0–3 days) meteorological variables via Spearman rank correlation. The same protocol is designed for iterative application across further taxa and seasons.

Both taxa began pollinating simultaneously (DOY 54) but peaked ten days apart (*Corylus avellana*: 4 March; *Alnus* sp.: 14 March). *Alnus* sp. showed a 62% higher SPI and a stronger lagged temperature response ($r_s = -0.408$ at lag-1). These onset, peak, duration, and intensity parameters constitute the core fields of a taxon-specific calendar entry.

As a single-season, two-taxon pilot, this study demonstrates rather than validates the approach. Extending it across the full allergenic flora and multiple seasons is the necessary next step toward a validated regional pollen calendar and its integration into a future national aerobiological monitoring network.

Keywords: aerobiology, pollen monitoring, pollen calendar, airborne pollen.

INTEGRATED ASSESSMENT OF CANAL WATER QUALITY IN SEMI-ARID REGION OF INDIA: HYDROGEOCHEMISTRY, IRRIGATION SUITABILITY, HEAVY METAL DISTRIBUTION, AND PROBABILISTIC HUMAN HEALTH RISK EVALUATION

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Canal water is a vital resource for irrigation and domestic use in Haryana, a semi-arid region in north-western India. This study presents an integrated assessment of canal water quality by combining hydrogeochemical characterization, irrigation suitability evaluation, heavy metal distribution, and probabilistic human health risk assessment. A total of forty two canal water samples were collected from major canal networks across seven districts and analyzed for physicochemical parameters, major ions, and selected heavy metals. Heavy metals were quantified using ICP–MS, while irrigation suitability was assessed through mathematical calculations. The results indicated that canal water is predominantly alkaline with generally low salinity. Total Hardness, Sodium Adsorption Ratio, and Sodium Percentage values were within permissible limits, suggesting overall suitability for irrigation. However, elevated Residual Sodium Carbonate, Kelly's Ratio, Magnesium Hazard, and Permeability Index values in several locations were recorded. Hydrogeochemical analyses revealed that carbonate and silicate weathering. Heavy metal concentrations showed marked spatial variability. While Cu, Cd, and Pb remained within permissible limits, As approached the guideline value in Hisar, Ni concentrations were elevated in Rohtak and Hisar, and Li exceeded recommended limits throughout the study area. Multivariate analyses suggested that anthropogenic activities, particularly agricultural and industrial inputs, are the dominant sources of contamination. Human health risk assessment demonstrated acceptable non-carcinogenic risks for adults, whereas children exhibited comparatively higher susceptibility. Carcinogenic risks remained within acceptable limits, with As and Cr contributing most significantly. The findings highlight the need for continuous monitoring and targeted management strategies to ensure sustainable water use and support SDGs 2, 3, and 6.

Keywords: canal water quality, heavy metals, human health risk assessment, hydrogeochemistry, irrigation suitability, sustainable development goals

KINETIC MEASUREMENTS AND ATMOSPHERIC LIFETIMES OF SUGAR ACIDS

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Sugar acids (SAs), including gluconic acid, glucuronic acid, and galacturonic acid, are commonly tracers of biomass burning and marine aerosols, and can also be formed in the atmosphere through oxidation of other saccharides. Due to their extremely low volatilities and a strong preference to reside in the aqueous phase, SAs contribute to atmospheric particulate matter and readily partition into water-containing particles. In clouds, reactions involving hydroxyl radical (•OH), the major daytime oxidant, can affect the formation and evolution of water-soluble organic compounds, resulting in fine organic aerosol formation. This work aimed to determine the pH- and temperature-dependent aqueous rate constants ($k_{OH_{aq}}$, M^{-1} s^{-1}) for these three SAs.

Kinetic measurements were conducted between 278 and 318 K, using the laser flash photolysis-long path absorption technique. New kinetic data, density functional theory (DFT) calculations, and structure–activity relationship (SAR) predictions were used to provide mechanistic insight into oxidation reactions and estimate the atmospheric lifetimes of the investigated SAs. The measured $k_{OH_{aq}}$ values of SAs ranged from 1.0 to 1.3 × 10^9 M^{-1} s^{-1}, consistent with literature data for similar molecules. For all SAs, $k_{OH_{aq}}$ values were temperature-dependent and followed the Arrhenius relationship, which was used to derive the activation parameters.

Both SARs and DFT indicate a preferential H-atom abstraction by •OH from C–H bonds. Moreover, SARs exhibited a moderate overestimation in predicting $k_{OH_{aq}}$ values for SAs and sugar alcohols. Estimated atmospheric lifetimes ranged from 7 min to 3.5 days, indicating that reactions of SAs with •OH can be relevant in cloud water under remote and marine conditions.

Keywords: sugar acids, aqueous rate constant, LFP-LPA, kinetic measurement, atmospheric lifetime

DOES LONG-TERM CEREAL MONOCULTURE NEGATIVELY AFFECT ORGANIC MATTER DECOMPOSITION?

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Long-term monoculture cultivation is known for its pernicious influence on soil organic matter decomposition efficiency. The soil ecosystem serves as habitat for different types of organisms encompassing insects, arachnids, earthworms, bacteria or fungi. The representatives of soil fauna play a substantial role in organic matter breakdown. Taking into consideration the fact that some of these organisms react dynamically to changes in soil conditions, their activity in organic matter decomposition can be used as a valuable tool in soil health assessment. The aim of this study was to indicate the impact of two long-term cereal monocultures on the process of organic matter decomposition. The field study was conducted in 2026 at the Research and Education Station in Swojczyce belonging to Wrocław University of Environmental and Life Sciences within a 60-year winter rye monoculture and a 36-year winter triticale monoculture. Research treatments in winter rye monoculture included three factors: conventional or reduced tillage systems, catch crops (buckwheat, white mustard, fodder radish, and common vetch) and application of soil conditioners: Groundfix Extreme (a microbial product produced by BTU-CENTER Europe GmbH) or MultiGeo (mineral fertilizer produced by Agresta). In winter triticale monoculture two factors were examined: conventional or reduced tillage systems and catch crops (white mustard or the mixture of buckwheat, white mustard, fodder radish, and common vetch). The study was arranged in a randomised block design with three replicates. The area of experimental plots was 6 x 10 m and 6 x 4 m for winter rye and winter triticale, respectively. The organic matter decomposition was measured by the use of two methods: bait-lamina test and litter bags filled with rye straw.

In total, the highest biological activity of soil organisms was recorded under reduced tillage with MultiGeo application in winter rye monoculture. On the other hand, in winter triticale monoculture, catch crops supported the process of organic matter decomposition in the most effective way when combined with traditional tillage. Nevertheless, straw was decomposed by soil organisms the most efficiently under traditional tillage and reduced tillage with catch crops. Overall, it can be assumed that soil regeneration treatments including reduced soil tillage, catch crops and application of soil conditioners are beneficial in terms of biological activity of soil arthropods and effectively diminish the negative impact of long-term monoculture cultivation on soil biological properties.

SELECTION OF PARAMETERS FOR THE ELECTROCHEMICAL OXIDATION OF PARACETAMOL USING A BDD ELECTRODE FLOW CELL

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Paracetamol is a persistent pharmaceutical pollutant frequently detected in urban wastewater, posing risks to aquatic organisms due to its continuous environmental release. Its widespread use and incomplete removal in conventional treatment plants make it an important indicator compound for evaluating advanced water treatment technologies. This study investigates its degradation using electrochemical advanced oxidation processes (EAOPs) with boron-doped diamond (BDD) electrodes, known for effective removal of resistant organic compounds.

Experiments were conducted in a flow-through electrochemical cell with BDD electrodes (active area: 48 cm^2) at a current density of 6.25 mA/cm^2 (0.3 A). A 50 mg/L paracetamol solution was electrochemically oxidized for up to 240 minutes. Sodium sulfate (Na_2SO_4) was used as the supporting electrolyte at 0.01 M and 0.10 M, and two flow rates (60 and 100 RPM) were tested. Degradation kinetics were evaluated using a pseudo-first-order model with rate constants determined by linear regression.

Nearly complete paracetamol removal was achieved within 60 minutes. At 0.01 M Na_2SO_4, degradation reached 82.8%, 94.9%, and 99.3% after 30, 45, and 60 minutes, respectively. At 0.10 M Na_2SO_4, degradation reached only 85.8% after 60 minutes, exceeding 98% only after 120 minutes. The inhibitory effect of higher electrolyte concentration is attributed to hydroxyl radical (•OH) scavenging by excess sulfate ions, identifying 0.01 M as the more favorable concentration.

Both flow rates yielded final degradation efficiencies exceeding 98%, with similar rate constants ($k \approx 0.009\ min^{-1}$), indicating the process was current-limited rather than mass-transfer-limited at 0.3 A.

Keywords: boron-doped diamond electrodes, electrochemical advanced oxidation processes, electrochemical degradation, process parameters fine-tuning, acetaminophen

This study was carried out within a project financed by the National Science Centre, Poland (no. 2023/51/I/ST8/02863).

IDENTIFICATION OF MICROPLASTICS IN ENVIRONMENTAL SAMPLES COLLECTED FROM MAHANANDA WILDLIFE SANCTUARY SITUATED IN THE EASTERN HIMALAYAS IN INDIA

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Microplastic pollution has been affecting biodiversity and human health globally. Very few studies on microplastics have been conducted till date in the expansive landscapes of the Himalayas. This study aims to identify and estimate microplastics present in the soil and freshwater of Mahananda Wildlife Sanctuary situated in the Eastern Himalayas in Darjeeling district, West Bengal, India. Both the water and soil samples were collected from different areas of the sanctuary. The microplastics were extracted by density separation, vacuum filtration, and oxidative digestion, followed by identification under optical microscope and quantified by ImageJ size analysis. A total of 211 microplastics were identified from four soil sampling sites, S11 (adjacent to road) with highest abundance (n = 84) and S13 the lowest (n = 31), while 34 microplastics were recorded from the water samples collected from the sanctuary (W-3). The average concentration was approximately 703.3 MPs/kg of soil and 75.6 MPs/liter of water. Fragments and fibers were the dominant morphotypes, and size distribution showed a right-skewed pattern with most particles below 0.2 mm. Statistical analysis confirmed significant differences in microplastic sizes across the sites (Kruskal–Wallis, $\chi^2 = 24.883$, $p < 0.001$). Tourism, transportation, and littering of wastes were identified as the possible reasons of microplastic pollution in the sanctuary area. Microplastic pollution in Mahananda Wildlife Sanctuary can affect the health of local wildlife, and can affect the endemic biodiversity. This study, for the first time, provides baseline data on microplastic pollution in the Mahananda Wildlife Sanctuary, highlighting the need for further research and conservation.

Keywords: Eastern Himalayas, Tourism, Soil, Freshwater, Microplastics

BIOREMEDIATION POTENTIAL OF WOOD-DECAY FUNGI ON CONTAMINATED RECYCLED WOOD: TOWARDS UPCYCLED MYCELIUM-BASED THERMAL INSULATION MATERIALS FOR CIRCULAR CONSTRUCTION

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Recycled post-consumer and post-industrial wood is an emerging feedstock for mycelium-based biocomposites (MBBs), yet it frequently carries residual organic contaminants inherited from its first life cycle, including polycyclic aromatic hydrocarbons (PAHs) from surface treatments and weathering, and formaldehyde released from urea- and phenol-formaldehyde adhesives used in particleboard, plywood, and oriented strand board. These residues raise processing and end-of-life concerns for circular reuse, while simultaneously representing a substrate-bound pollutant load that ligninolytic wood-decay fungi may be well placed to address. This contribution examines the bioremediation potential of selected wood-decay basidiomycetes, with emphasis on *Ganoderma* spp., cultivated on contaminated recycled wood, and evaluates how concurrent contaminant degradation and substrate colonisation can be integrated into the upcycling pathway toward thermal insulation biocomposites. We synthesise literature evidence on the white-rot ligninolytic enzyme system (laccase, manganese peroxidase, lignin peroxidase, versatile peroxidase) and its documented activity against PAHs and phenolic aromatic xenobiotics structurally related to formaldehyde-based adhesive residues, considered alongside our own substrate-selection and material-characterisation work on recycled-wood MBB insulation panels. The same oxidative enzymatic infrastructure that enables fungal colonisation and binding of lignocellulosic particles during MBB formation also drives degradation of recalcitrant aromatic pollutants, indicating that contaminant breakdown and composite consolidation can occur as a single concurrent process rather than as separate treatment and manufacturing steps. Framing fungal bioremediation and biocomposite formation as a unified process positions contaminated recycled wood as a viable, decontaminated feedstock for insulation MBBs, offering a concrete mechanism for closing material loops in circular construction.

Keywords: *Ganoderma*, bioremediation, recycled wood, mycelium-based biocomposites, thermal insulation

MICROBIAL DEGRADATION OF FUNGICIDES IN APPLE PRODUCTION: FROM LABORATORY STUDIES TO FIELD APPLICATIONS AND RISK ASSESSMENT

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The widespread use of fungicides in apple production contributes to effective disease control but may result in the presence of pesticide residues in harvested fruit. Biological approaches based on microorganisms have emerged as a promising strategy for enhancing pesticide dissipation and reducing consumer exposure. The aim of this study was to evaluate the biodegradation potential of selected microorganisms towards fungicides under laboratory and field conditions, and to assess the dietary risk associated with their residues in apples. Laboratory experiments investigated the degradation of fluopyram, tebuconazole, boscalid, pyraclostrobin and penthiopyrad by *Bacillus subtilis*, *Trichoderma harzianum* and their consortium. Growth inhibition assays were performed to determine the susceptibility of microorganisms to the tested compounds. Field trials were conducted in commercial apple orchards in southeastern Poland using commercial pesticides and biological preparations containing bacterial, fungal and yeast strains. Residue levels were determined by validated chromatographic methods based on QuEChERS extraction and GC-MS/MS analysis. Dietary exposure was estimated using supervised trial median residues (STMR) and expressed as a percentage of the acceptable daily intake (%ADI). Among the tested microorganisms, *T. harzianum* showed the highest degradation efficiency, reaching 83.7-99.4% for pyraclostrobin, whereas the lowest degradation was observed for tebuconazole 44.5-49.2%. The mixed microbial culture was most effective in boscalid degradation (64.7-66.8%). In field studies, biological treatments enhanced fungicide dissipation, although their effectiveness depended on apple cultivar and environmental conditions. The highest degradation was recorded for boscalid in the Gloster cultivar (52%) and for fluxapyroxad after Myco-Sin® application in Gala apples (59.9%). Dietary risk assessment demonstrated low consumer exposure, with %ADI values below 10% for children and below 3% for adults. The results indicate that microbial preparations can effectively support fungicide degradation in apple production systems, contributing to reduced pesticide residues and improved food safety while supporting sustainable crop protection practices.

Keywords: fungicides, biodegradation, microorganisms, apple orchards, food safety

FROM ENVIRONMENTAL MONITORING TO TERRITORIAL PLANNING: FOZWASE AS A MUNICIPAL SCIENCE-BASED APPROACH TO ESTUARINE GOVERNANCE

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Coastal and estuarine territories are increasingly exposed to water quality degradation, sediment disturbance, salinity changes, urban and industrial pressures, extreme hydrological events and climate-related risks. Within the framework of the European Mission “Restore our Ocean and Waters”, local monitoring initiatives can contribute to ecosystem protection, pollution prevention and more resilient territorial management.

This work presents the FozWaSe project, which is an Associated Region of DALIA – Danube Region Water Lighthouse Action and aims to replicate knowledge and methodologies from Demonstration Pilot Site 7 in the Danube Delta, adapting them to the Mondego estuary to support science-based municipal governance.

The project combines continuous environmental monitoring with field sampling campaigns focused on physico-chemical water parameters and sediment-related parameters. Preliminary water and sediment sampling results are integrated with a governance-oriented component based on stakeholder analysis. This analysis identified public authorities, operational entities, productive sectors, knowledge institutions and local users connected to the estuarine system. Focus groups are planned as the next step to validate the preliminary findings and collect technical and local knowledge.

Preliminary environmental results provide relevant information on water and sediment conditions in the Mondego estuary, contributing to the identification of spatial variability and the influence of natural and anthropogenic pressures. In parallel, the stakeholder analysis identified key actors, institutional responsibilities, interests, dependencies, potential conflicts and opportunities for cooperation. Together, these components create a basis for linking environmental evidence with municipal planning, climate adaptation and estuarine governance.

The FozWaSe experience shows that environmental monitoring can move beyond technical diagnosis when embedded in a municipal research and governance context. By linking European knowledge transfer, local environmental data, stakeholder engagement and territorial priorities, the project supports more anticipatory, participatory and resilient decision-making for coastal and estuarine regions.

Keywords: Environmental Monitoring, Estuarine Governance, Stakeholder Analysis, Water and Sediment Quality, Territorial Planning

ENVIRONMENTAL IMPACT OF LARGE FIRE OF CHEMICAL WASTE – A CASE STUDY FROM SIEMIANOWICE ŚLĄSKIE

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Landfill fires pose a serious threat to the environment and public health worldwide, releasing a variety of pollutants into the atmosphere and water. This article presents the results of research on the environmental impact of a large-scale fire involving illegally stored chemical waste in Siemianowice Śląskie, southern Poland, which occurred on May 10, 2024. The fire, which covered an area of 5,000 m^2, involved waste solvents, paints, and plastics, generating a smoke plume several kilometers high, visible from up to 30 km away. The research focuses on the direct environmental impacts. The meteorological conditions during the incident, characterized by a diffuse high-pressure field and a temperature inversion at an altitude of 1,800–2,100 m above sea level, significantly affected the dispersion of pollutants, initially preventing their vertical dispersion and then promoting horizontal spread. Particularly worrisome were the hazardous concentrations of highly toxic hydrogen cyanide, with the highest temporary concentration exceeding the background value by more than 1,500 times. Contaminated firefighting water entered nearby streams, necessitating the use of filter barriers to contain crude oil and petroleum products. Analysis of water samples revealed elevated levels of Kjeldahl nitrogen (21 mg N/l), total nitrogen (21.48 mg N/l), zinc (1.7 mg/l), and copper (0.49 mg/l), indicating significant contamination exceeding typical levels. These findings highlight the serious environmental risks posed by such incidents, emphasizing the need for effective waste management and emergency response strategies to mitigate widespread contamination and protect ecosystems.

Keywords: Landfill, Contamination, Risk assessment, water pollution

ECOLOGICAL TOXICITY OF PHARMACEUTICAL CONTAMINANTS IN PHARMACEUTICAL WASTEWATER

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The disposal of pharmaceutical wastewater has gained increasing attention due to its potential adverse effects on the environment and public health. Pharmaceuticals are an abundant group of emerging pollutants of significant importance due to their biological potency and potential to affect wildlife and humans. This study aims to assess the concentration of pharmaceutical contaminants and their toxicity to aquatic organisms. A qualitative research approach was used. Composite samples were collected from the effluent storage system. Various analytical techniques, including high-performance liquid chromatography (HPLC), were employed to detect and quantify pharmaceutical compounds in wastewater samples. The results revealed various pharmaceutical compounds (ibuprofen 28 *$*g/L, diclofenac 27.20 *$*g/L, paracetamol 22.03 *$*g/L, and tramadol <0.01 *$*g/L) in the wastewater. The maximal environmental concentration (MEC) for all the detected pharmaceuticals was high; hence, the risk quotients (RQs) indicated potential toxicity (RO > 1). It further indicates that the effluent was more toxic to the animals (daphnia and fish) than algae (plants). It can be concluded that pharmaceutical effluent was toxic to aquatic organisms. Therefore, there is a need to implement stringent regulatory measures to mitigate untreated pharmaceutical e0uent in water bodies. Addressing pharmaceutical contaminants in wastewater is crucial to safeguarding the environment and public health amid rising pharmaceutical use and production.

Keywords: analgesic, effluent, environmental matrices, pharmaceutical contaminants, toxicity

TRDMT1 AS A CYTOTOXIC FACTOR INCREASING THE SENSITIVITY OF OSTEOSARCOMA CELLS TO CAMALEXIN, BRASSININ AND ACETAMIPRID

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Acetamiprid, the only approved neonicotinoid for EU market, works as an inhibitor of acetylcholinesterase leading to hyperexcitation, paralysis and death. Camalexin (CAM) and brassinin (BRAS), natural indole phytoalexins, are mainly studied for their anticancer effect, but show also antiproliferative, antidiabetic, anti-inflammatory or antibiotic effect. **Aim:** Investigation of the role of *TRDMT1* (tRNA Aspartic Acid Methyltransferase 1) as a molecular factor increasing the sensitivity of osteosarcoma cells to BRA, CAM and acetamiprid alone or in combinations on human osteosarcoma 143 B cell line. Wild type (WT) and TRDMT1-knock out (TRDMT1-KO) cells were exposed to the concentrations 1, 2.5 and 5 $\mu g.ml^{-1}$ for 24 h. To assess chemicals effect alone or in combination, MTT test, mitochondrial oxidative stress induction, TUNEL assay and immunofluorescence imaging were performed. Data were statistical analysed. Significant metabolic changes (MTT test), more pronounced in TRDMT1-KO cells were found. Protective effect of phytoalexins against pesticide damage was not confirmed; chemicals were tested alone at the concentrations of 2.5 and 5 µg/ml. TRDMT1-KO cells were more prone to DNA fragmentation and ROS production was not significant. Changes in xenobiotic metabolism and cholesterol biosynthesis (cytochrome P450 and CYP51A1) were observed in TRDMT1-KO cells and in WT cells after BRA treatment. DNA damage was assessed by PARP1, 53BP1, RAD52 and TUNEL-stained breaks induction. PARP1 induction was detected in KO cells (BRA), 53BP1 foci induction in WT cells (BRA and CAM) and in TRDMT1-KO cells (pesticide and BRA). RAD52 reflects double strand breaks repairment; lower fluorescence intensity was detected in all tests. TUNEL-stained breaks were detected in higher levels in TRDMT1-KO cells ($p<0.001$) in comparison with WT. Absence of *TRDMT1* gene leads to an increase in the sensitivity of osteosarcoma cells to exposure.

Keywords: acetamiprid, brassinin, camalexin, DNA damage, metabolism

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ECOTOXICOLOGICAL EVALUATION OF PESTICIDE ACTIVE INGREDIENTS AND FORMULATIONS USING *FOLSOMIA CANDIDA*

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Plant protection products are widely used in modern agriculture to control weeds, insect pests, and fungal diseases. However, their extensive application has raised concerns about unintended effects on non-target soil organisms, which play essential roles in maintaining ecosystem functioning and soil health. Among these organisms, Collembola are widely used as model test species because they are abundant soil arthropods that contribute to organic matter decomposition, nutrient cycling, and soil fertility, while serving as sensitive indicators of soil contamination. Traditionally, environmental risk assessments have focused primarily on active ingredients, although commercial formulations also contain co-formulants that may affect the overall toxicity of these products. Therefore, evaluating both active ingredients and their corresponding commercial formulations is essential for improving the ecological relevance of pesticide risk assessment. This study aimed to compare the ecotoxicological effects of the active ingredients of a selected herbicide (glyphosate), fungicide (tebuconazole), and insecticide (lambda-cyhalothrin) with those of their corresponding commercial formulations on the reproductive response of Collembola under controlled laboratory conditions. Reproduction tests were performed according to OECD Test Guideline 232. For each pesticide group, one active ingredient and two corresponding commercial formulations were tested at three application levels representing half (0.5×), the recommended (1×), and double (2×) the recommended field dose. Reproductive performance was evaluated by counting the number of juveniles produced after the exposure period. Data were analyzed in RStudio using one-way ANOVA followed by Tukey's post hoc test after confirming normality and homogeneity of variance. The tested pesticides produced different effects on collembolan reproduction, with toxicity varying among pesticide groups, exposure concentrations, and between active ingredients and their corresponding commercial formulations. Overall, herbicide treatments exhibited the lowest reproductive toxicity, whereas fungicide and insecticide treatments caused more pronounced adverse effects. Furthermore, differences between active ingredients and commercial formulations suggest that co-formulants may contribute to the overall ecotoxicological response. These findings demonstrate that both pesticide type and formulation influence collembolan reproduction, highlighting the importance of including commercial formulations in environmental risk assessment to better reflect realistic exposure scenarios.

Keywords: Ecotoxicology, Plant protection products, Collembola, Pesticide formulations, Environmental risk assessment

TESTİNG THE PERFORMANCE OF EUROPEAN DİATOM INDİCES FOR EVALUATİNG THE ECOLOGİCAL STATUS İN SOM ERİVER BASİNS İN TÜRKİYE: KIZILIRMAK AND SAKARYA BASİN CASES

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Biological and physico-chemical monitoring have been applied in order to detect the effects of human activities on aquatic environments. Biological monitoring allows to analyse of this constatntly changing of physical and chemical characteristics of the water, giving a real reflection of conditions in aquatic environment. In the determination of ecological status, the most important factors have become the biological and hydromorphological elements. The ecological assessment of aquatic environments is base on four group of organisms: aquatic invertebrates, fishes, macrophytes and phytobenthos microorganisms – the diatoms. The diatoms are able to quickly react to changes in the water because of short life cycle. Another advantage of them is to have narrow ecological tolerance range. They are sensitive on salinity, temperature, pH, shading, water velocity, type of substratum, water chemistry, heavy metal contents, etc. They can be easily collected and stored for a long time. They are ideal organisms for water quality monitoring. The Sakarya River basin is one of the largest basins in Turkey, and encompasses the Kocaeli, Düzce, Sakarya, Bursa, Bilecik, Bolu, Kütahya, Eskişehir, Ankara, Afyon, and Konya provinces. The water quality status of the basin was investigated using 18 diatom indices, calculated in Omnidia software. For this purpose, a total of 46 stations were surveyed in the rivers and streams of the basin in 2018 and as a result, 41 of 195 diatom taxa were found to be the most frequent (>10% share in assemblage). The diatom index scores showed that the Descy's Index (DES), Pampean Diatom Index (IDP), Artois-Picardie Diatom Index (IDAP), and Specific Pollution Sensitivity Index (IPS) appear best suited to water quality assessment in this area, showing the largest number of significantly important correlation with environmental variables. The Kızılırmak River is the longest river (1.355 km) in Turkey and flows into the Black Sea. Also, the performance of the most widely used European diatom indices (IPS, IDG, IBD, EPI-D, TDI, and TI) was tested statistically by comparing them with the indicators of organic pollution (biological oxygen demand and ammonium-nitrogen), eutrophication (orthophosphate and nitrate-nitrogen) and salinization (electrical conductivity) in the basin, Türkiye. Totally, 97 diatom samples from 33 rivers were collected seasonally in 2014 and 2015 species were identified. As a result, EPI-D, IPS, IBD, and TI were strongly correlated indices, respectively, while IDG and TDI had the lowest correlations with general degradation. Only the EPI-D index was significantly correlated with all environmental variables. Our results showed that the EPI-D index can be used for the ecological status assessment in terms of phytobenthos in the Kızılırmak basin in line with the Water Framework Directive.

Keywords: diatom indices, ecological status, WFD

DETERMINATION OF MICROPLASTICS IN HTC-PROCESSED AND UNTREATED SEWAGE SLUDGE USING A NOVEL SINGLE-VESSEL EXTRACTION METHOD

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Microplastics (MPs) are emerging environmental contaminants with potential impacts on ecosystems and human health. Wastewater treatment plants effectively retain MPs, making sewage sludge a major sink and potential secondary source of these pollutants. Therefore, reliable MP determination in sewage sludge is essential for environmental monitoring and risk assessment. Hydrothermal carbonization (HTC) has gained attention as a sustainable sewage sludge treatment technology, providing stabilization, dewatering, and resource recovery. However, the effect of HTC on the fate of MPs remains insufficiently understood. Furthermore, the analysis of MPs in untreated sludge and HTC-derived hydrochar is challenged by complex matrices and multi-stage extraction procedures that may cause contamination and particle loss. This study aimed to develop extraction protocols for microplastic determination in untreated and HTC-processed sewage sludge using a novel single-vessel extraction method. Particular attention was given to highly carbonized HTC materials to achieve sufficient matrix purification for reliable LDIR analysis.

Untreated sewage sludge and HTC-derived hydrochar were processed using a patented density separator with an integrated reaction chamber. Sample preparation included pre-oxidation with 30% H_2O_2 at elevated temperature followed by Fenton oxidation. The reaction mixture was subsequently subjected to density separation using K_2CO_3 solution. Recovered particles were analyzed by Laser Direct Infrared (LDIR) spectroscopy.

The proposed method proved effective for both untreated sewage sludge and HTC-derived hydrochar. The patented separator enabled all preparation stages to be performed within a single vessel, minimizing contamination risk and material loss. MP abundance decreased from 2298 particles in sewage sludge to 1031 particles in hydrochar, while cumulative particle surface area decreased from 1.28×10^7 to 4.19×10^6 μm². HTC substantially reduced the occurrence of larger MPs (300–1000 μm), whereas particles smaller than 100 μm remained the dominant fraction (>88%) in both matrices.

The developed single-vessel protocol enabled reliable MP determination in complex sewage sludge and hydrochar matrices. The results indicate that HTC significantly reduces MP abundance, particularly larger particles, demonstrating its potential as a promising technology for mitigating microplastic contamination in sewage sludge management.

Keywords: Microplastics, Sewage sludge, Hydrothermal carbonization (HTC), Single-vessel extraction, LDIR spectroscopy

DECISION-SUPPORT APPROACH FOR WATER REUSE: WATERSAFE TOOL APPLICATION IN FINNISH WWTP

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In the face of increasing pressure on freshwater resources caused by climate change, urbanisation, and rising water demand, implementing safe and sustainable water reuse strategies has become an important element of modern water management. Treated wastewater is increasingly recognised as a valuable alternative water source. However, its reuse requires the selection of appropriate water recovery technologies that meet environmental standards. In this context, digital decision support tools can play a significant role in supporting the design, evaluation, and optimisation of water reuse systems by integrating technological, operational, and regulatory aspects within a unified assessment framework. This study aimed to validate the WaterSafe decision tool for water recovery and reuse using the example of the Kuopio-Lehtoniemi wastewater treatment plant in Finland. Wastewater quality data obtained from the treatment plant were entered into the WaterSafe tool to assess the feasibility of achieving selected reclaimed water quality classes under various reuse scenarios. The recommendations generated by the WaterSafe tool were then compared with technological configurations tested in laboratory studies, including advanced treatment processes such as ozonation, activated carbon adsorption combined with filtration, and UV disinfection. The comparative analysis demonstrated that the tool effectively supported the selection of appropriate treatment configurations and identified optimisation paths for water reuse applications. The obtained results confirmed the utility of the WaterSafe tool as a practical decision-support tool for planning and optimising water reuse systems, particularly in regions facing increasing water stress and stringent requirements of the European Union.

Keywords: WaterSafe tool, water reuse, reclaimed water, wastewater treatment, WWTP

ORGANIC-BASED PENETRATING AGENTS AS ADJUVANTS: A BOOST TO AGRICULTURAL EFFICACY OR A PHYTOPHYSIOLOGICAL LIMITATION?

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Pesticide residues are among the most common contaminants in agricultural soils and water, prompting efforts to reduce agrochemical use. Spray adjuvants can increase the effectiveness of foliar-applied formulations and reduce the required doses. However, their phytotoxic effects remain poorly characterized, particularly for novel penetrants such as the 1,3-dioxolanes DMD and TMD. Adjuvants are generally considered biologically inert. DMD and TMD are known to enhance the foliar uptake of co-applied compounds by improving spray solution properties, including surface tension and wettability. However, their direct effects remain unclear. This study therefore evaluated their effects on seed germination, root elongation, and seedling growth at agriculturally relevant concentrations. Phytotoxicity of DMD and TMD was assessed using two assays: a seed germination and root elongation test on Petri dishes (ISO 11269-1/2, OECD 208), and a vegetative vigor test (modified OECD 227) in which established seedlings were foliar-sprayed with the test formulations. Both dioxolanes were tested at 0.1%, 0.5%, 1%, and 2.5% concentrations, alone and in co-application with glycine betaine, across four species: *Sinapis alba*, *Brassica napus*, *Avena sativa*, and *Lepidium sativum*. Root elongation decreased in a concentration-dependent manner in all four species exposed to both 1,3-dioxolanes, reaching 81–85% inhibition for DMD at 2.5% in *Sinapis alba* and *Brassica napus*. Glycine betaine did not mitigate this effect and further intensified root growth inhibition when co-applied with DMD. In contrast, foliar spraying of established seedlings had a comparatively modest effect on shoot length and fresh mass, with the most stable responses observed in *Sinapis alba*; effects in the remaining species were more variable but showed no consistent dose-dependent trend. In the case of foliar spraying, which is common in agricultural practice, none of the compounds inhibited seedling growth. Marked inhibition occurred only during germination and root elongation, and only at the highest concentration. Both tests provide a sensitive and inexpensive basis for the preliminary ecotoxicological assessment of agricultural adjuvants.

Keywords: 1,3-dioxolanes, agricultural adjuvants, phytotoxicity, root elongation, ecotoxicological screening tests

THE ROLE OF PLANT BIOTECHNOLOGY IN THE SUSTAINABLE USE OF MEDICINAL PLANTS FOR ENVIRONMENTAL PROTECTION

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Medicinal plants are an important source of bioactive compounds widely used in the pharmaceutical, nutraceutical and cosmetic industries, as well as in traditional and modern medicine. Their increasing use has led to a growing demand for plant-derived raw materials, placing considerable pressure on natural populations, which, when combined with habitat degradation, climate change and unsustainable harvesting practices, raises concerns about biodiversity loss and the long-term availability of valuable medicinal plant resources. Consequently, there is a growing need for sustainable approaches that support both the conservation and responsible use of medicinal plants. Plant biotechnology has become an important tool in addressing these challenges by providing alternative methods for the propagation, conservation and production of medicinal plants. Current biotechnological approaches, such as micropropagation, plant tissue culture, hairy root cultures, bioreactor systems and cryopreservation, can help to reduce dependence on wild plant collection while ensuring a stable supply of high-quality plant material and valuable bioactive compounds. This paper discusses current plant biotechnology approaches that contribute to the sustainable use of medicinal plants and examines their potential role in environmental protection. Attention is given to the environmental benefits of these technologies, including biodiversity conservation, reduced harvesting of natural populations, more efficient use of natural resources and the development of environmentally sustainable production systems. Available findings indicates that plant biotechnology can significantly contribute to the conservation of medicinal plant diversity while supporting more sustainable production practices. Aside from making plant material more available, these technologies offer environmentally responsible alternatives that reduce pressure on natural ecosystems and promote the long-term preservation of valuable plant genetic resources. Overall, plant biotechnology represents an important component of sustainable medicinal plant management and has considerable potential to support biodiversity conservation and environmental protection.

Keywords: medicinal plants, plant biotechnology, sustainable use, environmental protection, plant tissue culture

URBAN ORGANIC RESOURCES IN THE TRANSITION TOWARDS A CIRCULAR BIOECONOMY

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Rapid urbanization has considerably increased the generation of organic municipal waste, sewage sludge, food waste, and other biodegradable residues. These resources are often landfilled, resulting in greenhouse gas emissions, nutrient losses, and the release of emerging contaminants. The transition to a circular bioeconomy requires sustainable solutions that convert urban organic waste into valuable secondary resources while minimizing environmental risks.

Aim: This study aims to assess the potential of urban organic resources for sustainable valorization within circular bioeconomy systems and to identify the main environmental benefits and challenges associated with their recovery and reuse.

The research is based on a review of recent scientific literature, European Union policy documents, and practical examples of urban bioresource management. Recovery pathways, including composting, anaerobic digestion, nutrient recovery, and bio-based material production, were comparatively evaluated in terms of resource efficiency, environmental performance, and contamination reduction. Particular attention was given to contaminants such as heavy metals, pharmaceutical residues, and microplastics that may affect the safe use of recycled organic materials.

Urban organic resources represent a valuable feedstock for renewable energy, organic fertilizers, soil amendments, and other bio-based products. Integrated biowaste management systems can reduce landfill disposal, decrease greenhouse gas emissions, and improve nutrient recycling. However, the presence of emerging contaminants remains a significant challenge, requiring advanced treatment technologies, continuous monitoring, and strict quality standards to ensure environmental safety.

Sustainable management of urban organic resources should become a key element of circular bioeconomy strategies. Integrating technological innovation, environmental monitoring, and appropriate regulatory frameworks can maximize resource recovery while minimizing environmental risks. Such approaches contribute to climate neutrality, environmental protection, and more efficient use of natural resources in urban areas.

Keywords: circular bioeconomy, urban organic resources, biowaste valorization, emerging contaminants, resource recovery

SELENIUM SEED PRIMING FOR IMPROVED CROP ESTABLISHMENT AND STRESS TOLERANCE

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Seed priming with mineral nutrients is a simple and cost-effective approach for improving seed performance under unfavourable conditions. Selenium (Se), although not essential for higher plants, can stimulate physiological and biochemical processes when applied at suitable concentrations. Nano-selenium has gained attention because its small particle size, large specific surface area and high reactivity may improve interaction with seed tissues. This review summarizes current knowledge on conventional Se and nano-Se seed priming, focusing on germination, early growth, antioxidant defense and tolerance to drought and salinity. Methods: Studies examining different Se forms, concentrations and crop species were reviewed, with emphasis on germination, seedling development and oxidative stress responses. Low to moderate Se concentrations generally improve germination, root and shoot growth, chlorophyll content and seedling biomass. These effects are associated with stronger antioxidant defence, greater membrane stability and reduced lipid peroxidation. Evidence on nano-Se priming remains limited, but available studies report improved germination and seedling growth, including positive responses in barley. Nano-Se may enable more efficient delivery than conventional Se; however, its effects remain dose-dependent. Responses vary with Se form, concentration, exposure duration, particle characteristics, species and genotype, while excessive doses may inhibit germination and cause toxicity. Conventional Se and nano-Se seed priming are promising approaches for improving crop establishment and stress tolerance. Crop-specific optimisation and field validation are needed to determine effective doses, safety and practical applicability.

Keywords: abiotic stress, antioxidant defence, germination, nano-selenium, seed priming, selenium

ECOPHYSIOLOGICAL RESPONSES OF *TRITICUM* SPP. TO ENVIRONMENTAL STRESS UNDER FIELD CONDITIONS

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In the context of ongoing climate change, crop production is increasingly challenged by a complex and intensifying array of abiotic and biotic stressors. These include altered and increasingly erratic precipitation regimes, recurrent drought episodes, extreme heat events, and the emergence of novel biological threats, including previously unrecognized or expanding populations of pathogenic fungi. To mitigate the adverse effects of climate change, foliar applications containing osmoprotectants or compounds involved in the regulation of plant stature may be employed. The efficacy of such treatments can be further enhanced through the use of adjuvants, which improve the delivery, retention, and overall effectiveness of the applied compounds. In the present study, foliar treatments were applied to field-grown wheat and comprised the osmoprotectant betaine and the plant growth regulator trinexapac-ethyl, either alone or in combination with 1,3-dioxolanes used as adjuvants. The experiment comprised six treatment variants: plots treated with water alone (control), the adjuvant alone, betaine alone, the plant growth regulator trinexapac-ethyl alone, betaine in combination with the adjuvant, and trinexapac-ethyl in combination with the adjuvant. Plant height and biomass were determined, while flag leaf parameters, gas exchange, pigment content, and photosynthetic apparatus performance were assessed. The applied agronomic treatments may contribute to maintaining or enhancing crop productivity under ongoing climate change. The results further indicate that 1,3-dioxolanes may serve as effective adjuvants, enhancing the performance of foliar-applied treatments.

Keywords: climate change, wheat, ecophysiological responses, betaine, trinexapac-ethyl, 1,3-dioxolanes

DRIVERS AND BARRIERS FOR SCALING ORGANIC SOIL IMPROVERS: A CROSS-REGIONAL SWOT ASSESSMENT

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Sustainable management of agricultural soils and transition to a circular economy are critical priorities in Europe. Repurposing food-processing residues into organic soil improvers offers a promising pathway to close nutrient loops, enhance soil health, and reduce reliance on synthetic fertilisers. The main objective of This study aimed to conduct a comprehensive Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to assess the internal and external factors influencing the deployment and market adoption of food waste-derived fertilising products across five European regions. The study involved Regional Working Groups and Living Labs in Denmark, Finland, Germany, Italy, and Spain. Data were collected through structured stakeholder workshops involving farmers, technology providers, and policymakers. The participants identified product-specific SWOT factors and quantitatively scored each attribute based on its impact significance and the effort required to address it. The data were synthesised using two-dimensional prioritisation impact-effort matrices and strategic radar charts to pinpoint actionable priorities. The SWOT analysis revealed significant internal strengths, including high technological readiness, abundant regional feedstocks, and proven agronomic benefits of biochar. However, critical weaknesses constrain scaling, primarily elevated energy and production costs, quality variability and complex processing logistics. External opportunities are heavily driven by alignment with European Union climate policies and the growing demand for circular bioeconomy solutions. Conversely, the sector faces severe external threats, notably aggressive price competition from conventional mineral fertilisers, missing harmonised quality standards, and farmer scepticism regarding product safety and yield reliability. Although organic soil improvers possess strong technological and environmental advantages, their market success is currently hindered by economic vulnerabilities and fragmented standardisation. Strategic scaling requires overcoming internal cost barriers and mitigating external market threats through targeted financial incentives and rigorous, transparent quality demonstrations.

Keywords: SWOT analysis, circular economy, organic fertilisers, food industry residues, strategic assessment

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PAHS ASSESSMENT OF PAH CONTAMINATION IN SOILS NEAR THE FORMER GLIMAR OIL REFINERY (GORLICE, POLAND) USING GC-MS/MS

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Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants widely distributed in the environment due to industrial activities, fuel combustion, and transportation. Former refinery sites are of particular interest because historical petroleum processing may contribute to long-term soil contamination. Owing to their persistence and affinity for soil organic matter, PAHs can accumulate in surface soils and serve as indicators of both past and ongoing anthropogenic pressure. The aim of this study was to evaluate PAH contamination in soils collected in the vicinity of the former Glimar oil refinery in Gorlice (southern Poland), identify potential sources of PAHs, and assess the influence of selected soil properties on their distribution. Soil samples were collected from eight locations and divided into surface (0-10 cm) and subsurface (10-30 cm) horizons. Sixteen priority PAHs were determined using fluidized-bed extraction, solid-phase extraction clean-up, and gas chromatography coupled with tandem mass spectrometry (GC-MS/MS). Soil pH, organic matter content (loss on ignition, LOI), and grain-size distribution were also analyzed. Potential PAH sources were identified using commonly applied molecular diagnostic ratios. Total PAH concentrations (Σ16PAH) ranged from 573.7 to 4610.6 ng g^{-1} dry weight, indicating moderate contamination typical of areas affected by mixed urban and industrial activities. High-molecular-weight PAHs predominated in all samples, accounting for the majority of total PAH content. Diagnostic ratios, including Ant/(Ant+Ph), Flt/(Flt+Pyr), IcdP/(IcdP+BghiP), BaA/(BaA+Chr), and ΣLMW/ΣHMW, consistently indicated a predominance of pyrogenic inputs associated with coal, biomass, and fossil fuel combustion. BaP/BghiP values suggested an additional contribution from traffic-related emissions. The highest contamination level was observed at sampling point 7A, where Σ16PAH reached 4610.6 ng g^{-1}. Elevated PAH concentrations were associated with higher organic matter content and finer soil fractions, confirming the importance of sorption processes in controlling PAH accumulation, whereas soil pH showed no clear relationship with PAH levels. The obtained results indicate that current combustion-related emissions, rather than historical refinery activities, are the dominant source of PAHs in the studied area. Soil organic matter and texture significantly influence PAH retention and distribution. The study demonstrates the usefulness of combining GC-MS/MS analysis with diagnostic ratios and soil property assessment for the identification of contamination sources and the evaluation of environmental quality in post-industrial areas.

Keywords: PAHs, soil contamination; source diagnostic ratios, GC-MS/MS, post-industrial areas

TURNING LOW-QUALITY CLAY MINERALS INTO HIGH-VALUE CATALYSTS: PHOTOCHEMICAL ELIMINATION OF EMERGING POLLUTANTS USING FE-BEARING MINERAL WASTE

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Natural clay minerals have attracted considerable attention as sustainable, low-cost catalysts and catalyst supports owing to their abundance, chemical stability, and tunable surface properties. In environmental applications, have been extensively investigated for the adsorption and catalytic degradation of organic pollutants, including pharmaceutical residues, dyes, pesticides, and emerging contaminants through photo-Fenton and photocatalytic processes. This study evaluates the potential of Fe-bearing clay mineral waste originating from a former clay mine as an inexpensive photocatalyst for the removal of emerging contaminants from water. Clay samples were subjected to organic acid treatment. The treated clays were either dried or calcined before catalytic evaluation. Photocatalytic degradation experiments were carried out in aqueous solutions containing diclofenac, triclosan, ketoprofen, ibuprofen, and carbamazepine. Pollutant concentrations were monitored by high-performance liquid chromatography (HPLC). The naturally Fe^{2+}-bearing clay exhibited significant photocatalytic activity toward the degradation of all investigated pharmaceuticals. Mild acid treatment slightly enhanced the catalytic performance, while calcination reduced photocatalytic efficiency, indicating that thermally induced mineralogical transformations adversely affected the availability or reactivity of iron species responsible for pollutant degradation. Naturally Fe^{2+}-bearing clay waste represents an effective, readily available, economically attractive photocatalyst for the degradation of emerging contaminants in water. Minimal chemical modification is sufficient to improve its performance, while avoiding energy-intensive thermal treatment contributes to a more sustainable and resource-efficient water remediation strategy.

Keywords: Fe-bearing clay minerals, Photocatalysis, Pharmaceuticals, Circular economy

PLANT-BASED TOXICITY ASSESSMENT AND PAH REMOVAL IN TREATED LANDFILL LEACHATE

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This study investigated associations between the physicochemical characteristics of landfill leachates and its phytotoxicity towards Sinapis alba, Lepidium sativum, and Sorghum saccharatum. In addition, the removal of polycyclic aromatic hydrocarbons (PAHs) during leachate treatment was evaluated.

Unvegetated treatment systems showed higher PAH-removal performance than vegetated configurations, reducing PAH concentrations by more than 90%. In systems amended with biochar, the difference in PAH removal between unvegetated and vegetated variants exceeded 60%. The longest hydraulic retention time (14 days) provided the most favourable treatment outcomes, including reductions of about 60% for three-ring PAHs and about 30% for four-ring PAHs. A stimulatory effect on plant response was observed irrespective of the treatment-system variant.

Untreated landfill leachates strongly inhibited plant growth and was highly phytotoxic to all tested species, with germination index values below 50%. By contrast, leachate treated at a 14-day hydraulic retention time caused no phytotoxic effects, as index values exceeded 100% in every bioassay. The tested plants differed clearly in their sensitivity to landfill leachates, with L. sativum generally displaying the greatest sensitivity.

Keywords: PAHs, landfill leachates, plants, germination index

EMPLOYING PLANT-PARASITIC NEMATODES AS BIOLOGICAL INDICATORS OF SOIL CONTAMINATION AND ECOSYSTEM HEALTH

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Soil degradation and contamination caused by anthropogenic activities significantly influence biological diversity and ecological functioning of terrestrial ecosystems. Nematodes are considered one of the most sensitive groups of soil organisms and are widely recognized as useful ecological indicators due to their rapid response to environmental changes. Previous research has shown that nematode communities are effective indicators of soil recovery processes and physicochemical transformations in terrestrial environments.

The study investigated the suitability of plant-parasitic nematodes as bioindicators of soil contamination and ecosystem health in environmentally transformed soils subjected to varying levels of anthropogenic pressure.

The analysis included the assessment of nematode abundance, community structure, trophic diversity, and relationships with selected physicochemical soil parameters, including pH, organic matter content, carbon-to-nitrogen ratio, phosphorus availability, and mineral element concentrations.

Clear shifts in plant-parasitic nematode community composition were observed along gradients of increasing soil disturbance. Impacted soils exhibited reduced nematode diversity and simplified community structures whereas less disturbed soils supported more balanced assemblages. Several plant-parasitic taxa showed strong associations with specific soil chemical parameters, indicating their sensitivity to environmental stressors and their potential diagnostic value in soil quality assessment.

Plant-parasitic nematodes represent informative and sensitive bioindicators of soil contamination and ecosystem condition. Their community-level responses provide integrative information on soil health and can support ecological risk assessment and monitoring of soil recovery processes.

Keywords: nematodes, bioindicators, environmental monitoring

CYTOTOXICITY OF WATER-AND ORGANIC-SOLUBLE TAR AEROSOLS GENERATED BY PYROLYSIS OF WOOD

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Fine atmospheric particulate matter (PM) is an important climate-forcing agent, affecting the climate and air quality; fine aerosols also pose a threat to public health. Exposure to fine and submicron aerosols has been associated with an increased prevalence of cardiovascular and respiratory conditions. Fine atmospheric PM is composed of various materials, often with a dominant contribution of organic compounds. Consequently, carbonaceous aerosols play a crucial role in the Earth system. Open biomass burning (BB), particularly vegetation fires, is one of the major global sources of pollutants. As such, BB emits large amounts of gases and PM into the atmosphere, including wood tar aerosol (the so-called tar balls), which originate from low-temperature pyrolysis and smoldering of forestry biomass. Moreover, due to rising global temperatures, climate change increases the frequency of wildfires, resulting in higher emissions of BB aerosols, which can introduce a human health problem due to exposure to BB PM. However, due to their complex composition, the mechanisms behind the adverse health impacts of tar balls emitted by BB remain poorly characterized.

This work aimed to investigate the cytotoxicity of wood-tar particles in A549 lung epithelial cells, which represent a primary site of exposure and injury in the human respiratory system. Tar-ball proxies were generated by pyrolysis of wood at 550°C and extracted using aqueous and organic solvents at concentrations ranging from 0 (control) to 150 ug/ml of PM. Toxicity was evaluated using the colorimetric assays, including 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide and lactate Dehydrogenase, as well as apoptosis detection assays. Both aqueous and organic extracts inhibited cell growth in a dose-dependent manner.

The data obtained provide new insights into the interplay between the chemical composition of PM and toxicity induced upon exposure to BB aerosols.

Keywords: Biomass Burning, Particulate matter, Wood tar aerosols, A549 cells, Cytotoxicity, Oxidative stress

INTEGRATING AERATED LAGOONS INTO MEMBRANE-BASED LEACHATE TREATMENT: TECHNO-ECONOMIC CHALLENGES AND FATE OF EMERGING CONTAMINANTS AT LVIV MSW LANDFILL

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Municipal solid waste (MSW) landfill leachate is a highly complex wastewater containing toxic organic compounds, heavy metals, and emerging contaminants like per- and polyfluoroalkyl substances (PFAS). In response to tightening environmental regulations, advanced physical-chemical and membrane processes are increasingly integrated into landfill management systems to achieve strict effluent standards. This study evaluates the techno-economic performance of integrating an aerated lagoon as a pre-treatment stage for reverse osmosis (RO) process at the Lviv MSW landfill, while modelling the potential fate, transformation, and removal pathways of PFAS.

Leachate samples from the aging Lviv MSW landfill were monitored after biological pre-treatment in aerated lagoon. Comprehensive physical-chemical analysis tracked changes in chemical oxygen demand (COD) and ammonium nitrogen (NH_4^+–N) across multiple replicates. Due to analytical limitations for direct PFAS measurement, the fate and distribution of these emerging contaminants were modelled using established literature correlations linking PFAS dynamics to COD and NH_4^+–N fluctuations.

Biological oxidation in the aerated lagoon effectively reduced NH_4^+–N by up to 76% and COD by up to 45%. Based on the modelled correlations, aerobic phase is expected to induce a significant shift in the PFAS profile via the oxidative transformation of polyfluorinated precursors into terminal perfluorocarboxylic acids (PFCAs). While a downstream RO stage is known to provide an excellent barrier (>95% rejection) for remaining PFAS, it inevitably leads to their accumulation in the membrane reject stream. Economically, aerobic pre-treatment successfully mitigated membrane fouling, reducing chemical cleaning frequency and RO operational costs by approximately 20–30%. Integrating aerated lagoons as a pre-treatment step significantly enhances RO membrane lifetime and reduces overall operational costs at old landfills. However, the modelled data suggests that biological oxidation alters the chemical speciation of emerging contaminants, emphasizing the need for targeted destructive post-treatment methods to eliminate PFAS from the generated RO concentrate.

Keywords: Aerated lagoons, Landfill leachate, Per- and polyfluoroalkyl substances (PFAS), Reverse osmosis

POSTER SESSION

ASSESSMENT OF AQUATIC SEDIMENT CONTAMINATION OF RESERVOIRS IN URBANISED AND INDUSTRIALISED REGIONS WITH RESPECT TO METALS IN THE CONTEXT OF CLIMATE CHANGE

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Aquatic reservoirs are vital to the environment and population. They are not only aesthetically pleasing but also provide health benefits and support biodiversity. Residents often use them for recreation. At the same time, these bodies of water provide important habitat and feeding grounds for wildlife. Due to their location in urban areas, they are susceptible to pollution from human activities. Progressive climate change, such as rising temperatures, changes in precipitation regimes, more frequent drought periods and extreme hydrological phenomena, may affect the processes of sedimentation, accumulation and remobilization of pollutants in water bodies. Consequently, these changes may alter the degree of exposure of the aquatic environment to metals accumulated in bottom sediments. The main goal of the research was to determine metal contamination in aquatic reservoirs in the cities of Upper Silesia and Krakow, taking into account the potential impact of climate change on the functioning of these ecosystems. Water, suspended matter, and bottom sediment samples were collected from selected reservoirs. The concentrations of metals (Cu, Zn, Cd, Fe, Ni, Pb, and Mn - AAS and ICP-MS methods), as well as selected physicochemical parameters (pH, Eh, EC, and T), were determined. The results were interpreted in light of current environmental regulations, geochemical background values, and the Igeo, LAWA, TEL, and PEL indices. The highest concentrations of metals were found in bottom sediments, particularly in the anthropogenic Hubertus reservoir in Katowice. Significantly higher concentrations were found for reservoirs in Upper Silesia than for Krakow. The maximum concentration were [mg/kg]: 52.82 for Cd, 1054.88 for Cu, 1865.84 for Pb, 8639.19 for Zn, 89.50 for Ni, 119097 for Fe and 2467.23 for Mn. The results confirm the long-term impact of historical metallurgical activity and location in the city centre on the environmental quality of the studied reservoirs and indicate that bottom sediments constitute an important reservoir of metals and may become a secondary source of contamination under changing environmental conditions.
Results also indicate the need for further research to more precisely identify the sources of pollution and develop effective methods for remediation. Given the existing metal contamination and the recreational functions of the studied reservoirs, particularly fishing, it is worthwhile to undertake actions to raise public awareness of the threats associated with environmental pollution from heavy metals.

Keywords: aquatic reservoirs, metals, historical contamination, climate changes

DETERMINATION OF THE CHEMICAL COMPOSITION OF FILTERS USED FOR TAP WATER FILTRATION

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Water is essential for life. Many water treatment plants declare that the water they purify is suitable for direct consumption. However, many homes still purchase bottled water or use water filter jugs. Tap water filters are often promoted as an environmentally friendly solution, as they help reduce the production of single-use plastic packaging. Jug manufacturers state that the filters contain ion exchange resin, responsible for removing certain heavy metals from water and minimizing limescale formation, and activated carbon, primarily responsible for improving taste and odour by reducing chlorine and organic compounds. The aim of the research was to check the chemical composition of jug filters and whether the pollutants they absorb could reflect the quality of the filtered water. Research focused on examining the chemical composition of the filters after their use and the content of elements released from them during water and acid washing (50% acetic acid). In order to estimate the content of organic matter and calcium carbonate, mass losses were analysed during roasting at temperatures of 550°C and 925°C, respectively. The total decomposition of the filter filling during mineralisation using aqua regia was also carried out. Thanks to this, it was possible to determine the content of metals and macro-elements. The obtained solutions were examined for the presence of 33 elements using ICP-MS method. Differences in the composition of filters were demonstrated due to different manufacturers and the composition of the water filtered by them. Some filters consist mainly of sodium 1126 mg per 100 g and other consist mainly of potassium 1199 mg per 100 g of the total filter mass. During water leaching, mainly minerals such as calcium (0.457-0.123 mg/L) and sodium (0.293-0.042 mg/L) and metals such as zinc (0.0036-0.00005 mg/L) are washed out. In an acidic environment, the amount of leached elements increases significantly, e.g. zinc (4.564-0.315 mg/L). Filters from different manufacturers, despite differences in composition, operate similarly. With their use, the concentration of potassium and sodium decreases and the content of calcium and magnesium in the filter filling increases, which proves that the absorbed pollutants may reflect the quality of the filtered water. Differences in the elements washed out are primarily due to differences between filter manufacturers, not the parameters of the water being filtered. The percentage of washed out elements in none of the elements exceeded 8%. Filters are not capable of significant changes in raising the water's pH. If filtered water becomes acidic, hazardous substances or previously absorbed minerals may be washed out of the filter, leading to deterioration of the filtered water's parameters.

Keywords: tap water, filtering, metals, water and acid leaching

OZONATION AS A GREEN PERSPECTIVE FOR MYCOTOXIN DEGRADATION IN PLANT RAW MATERIALS: EFFICIENCY AND BY-PRODUCTS PROFILE

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Mycotoxins, toxic secondary metabolites produced by filamentous fungi such as *Aspergillus*, *Fusarium*, and *Penicillium*, represent a critical challenge to global food safety and agricultural sustainability. Conventional physical and chemical decontamination methods often suffer from high energy consumption, nutrient loss, or harmful chemical residues. In response, gaseous ozonation has emerged as a highly efficient, eco-friendly, and zero-residue "green technology" for postharvest grain and plant raw material processing.

Ozone (O_3), a potent oxidizing agent, effectively disrupts the conjugated double bond systems essential for the toxicity of major mycotoxins, including aflatoxins (AFB_1), ochratoxin A (OTA), and trichothecenes (such as deoxynivalenol, DON, and T-2 toxin). This study reviews recent advancements in ozone-mediated mycotoxin degradation, focusing on process optimization (gas concentration, exposure time, and raw material moisture content) and kinetic modeling. Furthermore, particular attention is devoted to the chemical identification of degradation by-products formed during oxidation. Chromatographic and mass spectrometric evaluations (LC-MS/MS, GC-MS) reveal that ozone treatment substantially reduces parent toxin concentrations while converting them into significantly less toxic or non-toxic oxidized intermediates.

Crucially, when applied under optimized technological parameters (e.g., low-dose gaseous exposure), ozonation preserves the key quality attributes of plant matrices, including lipid stability, amino acid profiles, and organoleptic properties. Overall, gaseous ozonation stands out as a viable, scalable, and environmentally benign strategy for raw material decontamination in the agrifood sector, bridging the gap between stringent safety standards and sustainable postharvest engineering.

Keywords: Gaseous ozonation, Mycotoxin degradation, Food safety, Green processing, By-products profile, Deoxynivalenol, Aflatoxins

DETERMINATION OF THE LEVELS OF HEAVY METALS IN T-SHIRTS AND ASSESSING DERMAL EXPOSURE RISKS

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Many chemicals and heavy metals are used in textile manufacturing processes, including the dying process using azo dyes and metal complex dyes. People are exposed to heavy metals through daily contact with clothing. Some of these metals can cause allergic reactions and other adverse health effects. The aim of the study was to assess the heavy metal content in clothing and to estimate the health risks associated with dermal exposure to metals present in the tested clothing. Thirty-one T-shirts were used in the analysis. The analyzed garments were made of various fibers, colors, and some had prints. The T-shirts were produced in Asian countries, with the largest quantity coming from Bangladesh. The total metal content and the content of bioavailable forms were assessed using an artificial sweat solution. The highest metal contents were found in T-shirts made of natural fibers. Metal content ranged from 0.13 to 10.73 mg/kg for Cr, from 0.05 to 7.89 mg/kg for Ni, from 0.05 to 0.80 mg/kg for Pb, from 0.15 to 22.42 mg/kg for Zn, from 0.01 to 0.15 mg/kg for Cd, and from 0.05 to 605 mg/kg for Cu. Artificial sweat extraction demonstrated very low or trace bioavailability of metals. The obtained heavy metal contents in the tested clothing were at an acceptable level of non-carcinogenic risk (HQ < 1). The contents of some metals in the fabrics exceeded the limit values in the OEKO-TEX standard. The results demonstrate the validity of research on textile materials available on the market, not only in the context of heavy metals but also a wider range of harmful chemicals that may pose a threat to human health and the environment.

Keywords: heavy metals, cotton, synthetic fabrics, health risks, textile safety

AGRICULTURAL WASTE BIOCHAR AS A LOW-COST ADSORBENT FOR PHARMACEUTICAL AND ANTIBIOTIC REMOVAL FROM CONTAMINATED WATER

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Pharmaceutical residues and antibiotics are increasingly detected in aquatic environments due to continuous discharge from domestic wastewater, healthcare facilities, livestock production, and pharmaceutical use. This study evaluated the effectiveness of two agricultural waste-derived biochars, rice husk biochar and corn cob biochar, as low-cost adsorbents for the removal of selected pharmaceutical and antibiotic contaminants from contaminated water. Rice husk and corn cob residues were converted into biochar under controlled pyrolysis conditions. The produced biochars were characterized for key physicochemical properties, including pH, electrical conductivity, ash content, volatile matter, fixed carbon, surface functional groups, and surface morphology. Batch adsorption experiments were conducted to assess the influence of biochar type, adsorbent dosage, contact time, solution pH, and initial contaminant concentration on contaminant removal. The findings showed that both rice husk biochar and corn cob biochar were effective in reducing pharmaceutical and antibiotic contaminants from wastewater, although removal performance varied between the two biochar types and across experimental conditions. The differences in adsorption behaviour were linked to variations in feedstock-derived properties, including carbon content, ash composition, surface morphology, and functional groups. Removal efficiency improved with increased contact time and adsorbent dosage, while solution pH influenced adsorption by affecting biochar surface charge and contaminant speciation. The observed adsorption behaviour was attributed to a combination of pore filling, electrostatic attraction, hydrogen bonding, π–π interactions, hydrophobic interactions, and interactions with surface functional groups. The study demonstrated that rice husk biochar and corn cob biochar are promising, affordable, and environmentally sustainable adsorbents for the treatment of water contaminated with pharmaceutical and antibiotic residues. The findings support the valorization of agricultural waste into functional materials for water purification, particularly in low-resource settings where advanced wastewater treatment technologies may be costly or inaccessible.

Keywords: biochar, pharmaceuticals, antibiotics, contaminated water, wastewater treatment

SUSTAINABLE DAIRY LOGISTICS AND ENVIRONMENTAL FOOTPRINT REDUCTION IN SHORT FOOD SUPPLY CHAINS

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Food production and distribution systems contribute significantly to greenhouse gas emissions, resource consumption, and food losses. Growing concerns about environmental sustainability, climate change, and supply chain disruptions have increased interest in short food supply chains as a means of reducing environmental pressure while supporting food security. Local dairy production systems may reduce transport-related emissions, limit food waste, and strengthen the resilience of regional food networks. The aim of this study was to assess the environmental and logistical aspects of local dairy distribution systems and to evaluate consumer perceptions of sustainable food supply solutions using the example of a small-scale artisanal cheese producer. The study combined a consumer survey (n = 100) with a case study of the family-owned cheese producer "Pasja Sera" located in south-eastern Poland. The survey examined consumer preferences regarding local food purchasing, environmentally friendly distribution methods, and innovative logistics solutions. The case study focused on sourcing strategies, transport organisation, cold-chain management, and sustainable distribution practices. Consumers demonstrated a strong preference for local food products and recognised their environmental and social benefits. The most preferred distribution channels were partner stores (39%) and direct home delivery (28%). Limited accessibility of sales points and logistical barriers were identified as factors reducing the attractiveness of local food systems. The analysed enterprise sourced raw materials exclusively from farms located within a 60 km radius, reducing transport distances and associated carbon emissions. During the COVID-19 pandemic, diversified distribution channels, digital management systems, and local sourcing enabled the company to maintain supply continuity while minimising environmental burdens related to long-distance transport. The results indicate that short dairy supply chains can support food security, reduce transport-related environmental impacts, and enhance the resilience of local food systems. The integration of local sourcing, product traceability, and digital logistics solutions may contribute to the development of more sustainable agri-food supply networks.

Keywords: climate resilience, environmental footprint, green logistics, rural development, responsible consumption

TREATMENT OF CONTAMINATED AQUATIC ENVIRONMENTS USING MAGNETICALLY RESPONSIVE BIOCHAR ADSORBENTS

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The removal of organic dyes from industrial wastewater remains a major environmental challenge due to their high toxicity and persistence. Biochar derived from lignocellulosic biomass is considered a promising low-cost adsorbent; however, its practical application is limited by the difficulty of separating fine carbon particles from treated water. Magnetically responsive biochars offer an attractive solution by combining high adsorption performance with rapid magnetic recovery. This study aimed to develop magnetically responsive biochars from different lignocellulosic feedstocks and to elucidate the relationship between the synthesis route, structural characteristics, magnetic properties, and adsorption performance toward methylene blue (MB) and Congo red (CR). Wheat straw and sugar beet pulp were used as biomass precursors, while $FeCl_3$ and $ZnCl_2$ served as activating agents. Magnetic biochars were prepared via one-stage and two-stage pyrolysis under an argon atmosphere. Phase composition was analyzed by X-ray diffraction, magnetic properties by vibrating sample magnetometry, pore characteristics by nitrogen adsorption-desorption analysis, and adsorption performance by equilibrium adsorption experiments using MB and CR. All synthesized materials consisted of an amorphous carbon matrix containing ferrimagnetic Fe_3O_4 nanoparticles. Two-stage pyrolysis significantly enhanced pore development, increasing the specific surface area from 405.2 to 884.7 $m^2\ g^{-1}$ for wheat straw biochar and from 280.3 to 450.1 $m^2\ g^{-1}$ for sugar beet pulp biochar. Magnetic measurements indicated the formation of smaller Fe_3O_4 magnetic domains after two-stage synthesis. Adsorption isotherms were best described by the Langmuir model. The highest adsorption capacities were obtained for two-stage wheat straw biochar, reaching 151.5 mg g^{-1} for MB and 99.8 mg g^{-1} for CR. Wheat straw-derived biochars consistently outperformed those produced from sugar beet pulp. Two-stage synthesis effectively improves the porous structure, magnetic characteristics, and adsorption efficiency of biochars. The combination of high adsorption capacity and magnetic separability makes wheat straw-derived magnetic biochar a promising adsorbent for the treatment of dye-contaminated aquatic environments.

Keywords: magnetic biochar, wastewater treatment, adsorption; methylene blue, Congo red

FRESH VERSUS CANNED FISH AND SEAFOOD AS DIETARY SOURCES OF ^{210}PO AND ^{210}PB

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Natural radionuclides ^{210}Po and ^{210}Pb are present in aquatic environments and may accumulate in organisms consumed as part of the human diet. The aim of this study was to determine the activity concentrations of ^{210}Po and ^{210}Pb in fresh and processed fish and molluscs available on the Polish market, as well as to assess the effects of species, storage conditions, packaging type, and processing methods on the levels of these radionuclides. Potential consumer exposure resulting from the consumption of the products analysed was also evaluated. Among processed products, the highest activity concentrations of ^{210}Po and ^{210}Pb were measured in sardines and octopus, respectively, whereas the lowest concentrations were found in lake salmon and mackerel. Among fresh fish and molluscs, the highest concentrations were observed in New Zealand ling and Mediterranean mussel, respectively, while the lowest were detected in rainbow trout and Atlantic herring. No statistically significant effect of the type of packing medium on either ^{210}Po or ^{210}Pb concentrations was observed. However, ^{210}Po concentrations differed significantly depending on storage conditions and product type; significant differences were found between canned fish, vacuum-packed fish, freshly caught fish, and aquaculture products. In the case of ^{210}Pb, no significant effect of packaging method was observed, whereas significant differences in activity concentrations were found among individual fish and mollusc species. The estimated doses resulting from the consumption of products containing the highest radionuclide concentrations amounted to only a fraction of a µSv per year, indicating a very low radiological risk associated with their consumption. At the same time, the results demonstrate that species, processing methods, and storage conditions may affect the levels of ^{210}Po and ^{210}Pb in fish and seafood and should therefore be considered when assessing their contribution as dietary sources of naturally occurring radionuclides.

Keywords: ^{210}Po, ^{210}Pb, fish, seafood, radionuclides

THE ROLE OF SECONDARY PLANT METABOLITES IN ENHANCING THE DEGRADATION AND DETOXICATION OF PESTICIDES IN AGRICULTURAL SOILS

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Modern intensive agriculture relies heavily on pesticides, which can persist in the soil matrix far beyond their predicted half-lives, threatening environmental sustainability and groundwater quality. While abiotic factors like pH are often studied, the biochemical role of the rhizosphere and secondary plant metabolites (SPMs) as natural mediators in pesticide dissipation remains a critical knowledge gap. This study evaluates how specific phenolic acids (e.g., p-hydroxybenzoic, vanillic, syringic, and p-coumaric acids) influence the degradation kinetics of five chemically diverse pesticides: fluroxypyr, acetamiprid, pirimicarb, tebuconazole, and azoxystrobin. The hypothesis states that these compounds can stimulate microbial communities and mitigate ecotoxicological pressure on soil organisms. An integrative approach was developed, combining laboratory experiments and semi-field mesocosm trials across diverse soil textures. Pesticide concentrations were monitored using a QuEChERS-based protocol and LC-MS/MS analysis, while biological integrity was assessed via enzymatic profiling and ecotoxicological assays, including MARA, Microtox, and tests with Eisenia fetida and Folsomia candida. The research is expected to identify mechanistic synergies between plant-derived antioxidants and degradation pathways, monitoring how SPMs modulate soil redox conditions. It is anticipated that these interactions will facilitate the breakdown of persistent residues and enhance the self-purification capacity of agricultural soils.
These expected findings will aim to provide practical guidelines for using plant-based soil amendments to naturally accelerate land detoxication. The project's outcomes are intended to support "green" strategies for soil remediation, facilitating the transition towards a circular bioeconomy and safer food production.

Keywords: Secondary plant metabolites, Pesticide degradation, Soil remediation, Phenolic acids, Ecotoxicity

Acknowledgement: This work was supported by the National Science Centre, Poland, under the project OPUS 29, grant no. 2025/57/B/ST10/01727, entitled "Influence of secondary plant metabolites on degradation of pesticides in agricultural soils" (2026–2029).

TRANSFORMATION OF MUNICIPAL SEWAGE SLUDGE INTO ENVIRONMENTALLY SAFER ORGANIC-MINERAL FERTILIZERS: CHALLENGES AND PERSPECTIVES

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Municipal sewage sludge represents a valuable source of organic matter as well as macro- and micronutrients. However, its agricultural and environmental use raises numerous concerns due to the presence of heavy metals, organic pollutants, pathogens, microplastics, and substances classified as emerging contaminants. Additional limitations arise from the unfavorable physical properties of sewage sludge, including its high moisture content, high viscosity, and odor nuisance, which complicate storage, transportation, and land application.

The aim of this study is to present the current challenges and future perspectives associated with the transformation of municipal sewage sludge into fertilizers with enhanced environmental safety and improved functional properties.

An analytical and critical review approach was adopted based on recent scientific publications indexed in the Scopus and Web of Science databases, European Union strategic documents, and current legal regulations concerning the management of municipal sewage sludge. Particular attention was paid to the production of organic-mineral fertilizers derived from sewage sludge, as well as to technological solutions aimed at reducing contaminant mobility and improving the application properties of fertilizer products.

The conventional assessment of the quality of organic-mineral fertilizers from sewage sludge is primarily based on basic chemical and sanitary parameters. Modification of the composition and physical properties of sewage sludge, e.g. by adding a mineral materials, can reduce the mobility of heavy metals, improve the sorption capacity and application properties of the final product, mitigate odor emissions, and enhance public acceptance of its environmental use. Properly designed sludge processing technologies enable both an increase in fertilizer value and a reduction in the environmental risks associated with the presence of contaminants.

The development of municipal sewage sludge processing technologies should focus on the production of safe, stable, and efficient fertilizers that enable the recovery of valuable nutrients while minimizing environmental impacts. Such an approach is fully consistent with the principles of the circular economy and current trends in environmental engineering.

Keywords: municipal sewage sludge, organic-mineral fertilizers, environmental safety, circular economy, nutrient recovery

THE ROLE OF SECONDARY PLANT METABOLITES IN ENHANCING THE DEGRADATION AND DETOXICATION OF PESTICIDES IN AGRICULTURAL SOILS

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Modern intensive agriculture relies heavily on pesticides, which can persist in the soil matrix far beyond their predicted half-lives, threatening environmental sustainability and groundwater quality. While abiotic factors like pH are often studied, the biochemical role of the rhizosphere and secondary plant metabolites (SPMs) as natural mediators in pesticide dissipation remains a critical knowledge gap. This study evaluates how specific phenolic acids (e.g., p-hydroxybenzoic, vanillic, syringic, and p-coumaric acids) influence the degradation kinetics of five chemically diverse pesticides: fluroxypyr, acetamiprid, pirimicarb, tebuconazole, and azoxystrobin. The hypothesis states that these compounds can stimulate microbial communities and mitigate ecotoxicological pressure on soil organisms. An integrative approach was developed, combining laboratory experiments and semi-field mesocosm trials across diverse soil textures. Pesticide concentrations were monitored using a QuEChERS-based protocol and LC-MS/MS analysis, while biological integrity was assessed via enzymatic profiling and ecotoxicological assays, including MARA, Microtox, and tests with Eisenia fetida and Folsomia candida. The research is expected to identify mechanistic synergies between plant-derived antioxidants and degradation pathways, monitoring how SPMs modulate soil redox conditions. It is anticipated that these interactions will facilitate the breakdown of persistent residues and enhance the self-purification capacity of agricultural soils.
These expected findings will aim to provide practical guidelines for using plant-based soil amendments to naturally accelerate land detoxication. The project's outcomes are intended to support "green" strategies for soil remediation, facilitating the transition towards a circular bioeconomy and safer food production.

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INTEGRATING SOIL REMEDIATION AND WATER TREATMENT: PHOTOCATALYTIC REUSE OF ORGANIC ACID-TREATED CLAY MINERALS FOR EMERGING POLLUTANT REMOVAL

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Soil contamination by heavy metals remains a major environmental challenge, particularly at former mining and industrial sites. Although numerous remediation techniques have been developed, less attention has been paid to the subsequent utilization of remediated mineral materials. Developing strategies integrating soil remediation with environmental applications would improve resource efficiency and support circular economy principles. Clay minerals are attractive candidates because of their abundance, stability, iron-bearing phases, and potential catalytic activity after chemical treatment. The study aimed to investigate whether clay minerals recovered from a former clay mine after heavy metal decontamination could be repurposed as photocatalysts for the degradation of emerging organic contaminants in water, thereby coupling soil remediation with wastewater treatment. Clay-derived mineral material was characterized for its heavy metal content using atomic absorption spectrometry (AAS). Decontamination was performed using low-molecular-weight organic acids (acetic and citric acids), and metal removal efficiency was evaluated. The treated minerals were tested as adsorbents and photocatalysts toward selected pharmaceuticals and personal care products, including carbamazepine, ketoprofen, ibuprofen, diclofenac, and triclosan. Pollutant removal was monitored under UV irradiation by high-performance liquid chromatography (HPLC). Organic acid treatment effectively reduced the heavy metal content while preserving the mineral matrix. The decontaminated clays exhibited negligible adsorption capacity toward the investigated contaminants, indicating that physical sorption was not the dominant removal mechanism. Nevertheless, they demonstrated pronounced photocatalytic activity, resulting in efficient degradation of diclofenac, triclosan, and ketoprofen under UV irradiation. The retained iron-bearing mineral phases are believed to play a key role in the observed photocatalytic performance. Organic acid-treated clay minerals represent a promising example of post-remediation material valorization. Their direct reuse as low-cost photocatalysts integrates soil remediation and water treatment within a circular resource management framework, offering an environmentally and economically sustainable alternative to disposing of remediated mineral wastes.

Keywords**:** Clay mineral valorization, Organic acid treatment, Water treatment, Photocatalysis

FROM WILD HARVESTING TO CULTIVATION: INTRODUCTION OF *ARNICA MONTANA* L. AS A PREREQUISITE FOR CONTROLLED PRODUCTION OF MEDICINAL RAW MATERIAL

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Arnica montana L. raw material is traditionally harvested from wild mountain grasslands – areas exposed to atmospheric deposition and grazing, where origin and purity remain uncontrolled. The species has limited resources, occurring in Ukraine only in the Carpathians, and its removal from the wild is regulated in the EU under Annex V of the Habitats Directive. Cultivation could both relieve pressure on wild populations and enable quality control, yet transfer of this montane species to foothill conditions remains poorly studied. To assess the feasibility of introducing *Arnica montana* L. of Carpathian origin into foothill conditions over four years. A collection plot was established in spring 2023 in the Druzhba Dendrological Park of National Importance of Vasyl Stefanyk Carpathian National University (Ivano-Frankivsk, ca. 250 m a.s.l.). Fifteen plants were transferred from a natural population on the Hadzhyna mountain pasture, Chornohora (ca. 1205 m a.s.l.), a difference of about 950 m. During the growing seasons of 2023–2026, survival, phenological phases and morphometric parameters were recorded: plant height, rosette diameter, leaf number and size, and the number and diameter of generative shoots and flower heads. Flowering dates were compared with those of the source population. Survival over the entire period was 100%. Plants entered the generative phase and flower consistently, producing several shoots and heads per individual. In every season, flowering began about two weeks earlier than in the source population, consistent with the expected response to reduced altitude. *Arnica montana* L. of Carpathian origin retains viability and generative capacity 950 m below its natural altitudinal belt, confirming that cultivation under foothill conditions is feasible. This provides a basis for subsequent assessment of the quality and purity of cultivated material.

Keywords: *Arnica montana* L., introduction, medicinal raw material, phenology, Carpathians

BIODIVERSITY OF MICROBIOME AND MYCOBIOME OF LONG-TERM OIL-CONTAMINATED SOILS

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The main condition for effective bioremediation of contaminated soils is the presence of microorganisms capable not only of catabolic degradation of pollutants, but also having a number of other properties confirming their biotechnological and adaptive potential. The ability of a natural environment contaminated with harmful substances to self-cleanse is still a mystery to the world of science. During long-term contamination and self-progressing natural bioremediation, the soil becomes richly populated by spontaneous ruderal vegetation. The rhizosphere of these plants is a unique habitat for various bacteria and fungi with high biotechnological potential. Both microorganisms and plants adapting to growth in contaminated conditions can develop a number of defense mechanisms. Relict vegetation is also characterized by great genetic, physiological and metabolomic diversity. Plants adapted to grow in a polluted area may have (or develop) unique characteristics. The main objective of the study is to explain the role of ruderal vegetation, its rhizosphere, autochthonous microorganisms in the processes of natural, spontaneous bioremediation of soils that have been polluted for many years. The specific objectives of the study include: explaining how relict plants activate and develop their adaptation and defense mechanisms; defining the role and explaining the adaptive mechanisms of microorganisms in the processes of long-term natural bioremediation. Both soils and plants were collected from under crude oil extractors in the historic Oil Mine in Węglówka. These areas have been heavily polluted and degraded (over 100 years of pollution). Nevertheless, from the closure of the mine to the present, crude oil has continued to flow spontaneously from oil wells. The constant flow of crude oil causes permanent pollution of the area while spontaneous, natural remediation is progressing. The area is also richly covered with relic vegetation. Soil samples were collected from selected 9 oldest oil wells. 5 species of ruderal plants were selected for research. DNA was extracted directly from the soil and rhizosphere. Isolation and characterization of bacterial and fungal strains isolated from the rhizosphere and endorizosphere of ruderal plants were performed. The strains were assessed on the basis of morphological, biochemical and genetic tests. The following analyses were determined: functional diversity using the Biolog system, next generation sequencing (NGS) of variable regions (16S rRNA for bacteria and ITS for fungi) and viral NGS (Shotgun sequencing). In addition, the chemical parameters of plant and soil samples (Corg, Nmin, Σ16 PAHs and trace elements) were determined. In the plants the following analyses were assessed: biological activity of selected secondary metabolites, determination of the metabolomic profile and the content of phenolic compounds.

Keywords: natural remediation, rhizosphere, microbiome, petroleum contamination,

The research was is part of the project: NCN 2022/45/B/NZ8/02398 "The interaction between the microbiome, mycobiome and metavirion of the rhizosphere and endorhiosphere of ruderal plants and their role in the passive and active remediation of heavily degraded soils and long-term oil pollution" (2023- 2027).

COMPARATIVE ANALYSIS OF POLYCYCLIC AROMATIC HYDROCARBON (PAHs) CONTENT IN SOILS FROM CITY PARKS IN RZESZÓW AND KRAKÓW USING THE GC-MS/MS TECHNIQUE

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Polycyclic aromatic hydrocarbons (PAHs) are persistent environmental pollutants originating mainly from anthropogenic activities, particularly road traffic and fossil fuel combustion. Urban park soils act as important sinks for these compounds, making their monitoring essential for assessing environmental quality and potential human exposure. The aim of this study was to compare the concentrations and spatial distribution of selected PAHs in soils collected from urban parks in Rzeszów and Kraków using gas chromatography coupled with tandem mass spectrometry (GC-MS/MS). Soil samples were collected from 25 parks located in Rzeszów and Kraków, with sampling points located both near roads and in the central parts of the parks. Thirteen PAHs, including acenaphthylene, fluorene, phenanthrene, anthracene, pyrene, chrysene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene and dibenzo(a,h)anthracene, were determined. Samples were extracted using the QuEChERS multiresidue method and analysed by GC-MS/MS. PAHs were detected in all analysed soil samples, although their concentrations varied considerably between locations. In both cities, soils collected near roads consistently contained higher PAH levels than samples from park interiors. Elevated concentrations of high-molecular-weight PAHs, including pyrene, chrysene, benzo(a)anthracene, and benzo(b)fluoranthene, were observed particularly in parks situated close to major traffic routes. The most polluted of the studied parks were Park Dąbie of Kraków and Plac Getta of Rzeszów. Overall, Kraków parks exhibited a greater number of sites with elevated PAH concentrations than those in Rzeszów, reflecting the higher anthropogenic pressure associated with a larger and more densely trafficked urban environment. The obtained results demonstrate that road traffic is a major source of PAH contamination in urban park soils and that pollutant accumulation decreases with increasing distance from traffic corridors. The higher contamination observed in Kraków highlights the influence of urbanization intensity on soil quality. Continuous monitoring of PAHs in urban green spaces is therefore essential for environmental protection and sustainable urban management.

Keywords: polycyclic aromatic hydrocarbons (PAHs), urban soils, GC-MS/MS, QuEChERS, environmental pollution

MUNICIPAL PARKS AS EARLY WARNING SYSTEMS FOR SOIL CONTAMINATION – INSIGHTS FROM RZESZÓW'S RECREATIONAL AREAS

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With continuing urbanization and industrial growth, more attention is being paid to the quality of the urban environment. Green spaces, especially municipal parks, are a valuable part of densely built cities. Since many people use these parks daily and pollutants are becoming more widespread, the question arises as to whether these parks are completely safe. Traffic-related pollution, including heavy metals from exhaust fumes, tire wear, and road abrasion, is considered a major threat to urban soils. This study aimed to evaluate soil quality in city parks in Rzeszów, Poland, with focus on the influence of road proximity on the accumulation of potentially toxic elements. Soil samples were taken from two points in each park: one near the road and another in the central part. Inductively coupled plasma mass spectrometry (ICP-MS) was used to measure a wide range of elements, including key toxic metals such as lead, cadmium, chromium, and nickel. The analyses did not show any toxic elements exceeding permissible limits, indicating that the studied soils are generally satisfactory. However, even seemingly low concentrations of some metals, especially cadmium and lead, may have harmful effects on living organisms over longer periods. These results highlight the importance of systematic, long-term monitoring of soil in recreational areas. Only with regular monitoring can it be ensured that urban parks remain safe for the public, and that potential risks are detected early enough for appropriate action.

Keywords: municipal parks, soil contamination, heavy metals, traffic emissions, ICP-MS

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APPLICATION OF ANTIBACTERIAL DAT7/REDOX ACTIVE FILM FOR IMPROVING MICROBIOLOGICAL WATER QUALITY IN REUSABLE BOTTLES: PUBLIC HEALTH IMPLICATIONS

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Microbiological safety of drinking water remains a significant global challenge, with more than 2 billion people lacking access to safe water sources. An additional concern is secondary contamination occurring during water storage. The aim of this study was to evaluate the antibacterial activity of DAT-7 foil coated with a REDOX layer deposited by physical vapor deposition (PVD) under both controlled laboratory and practical application conditions. Antimicrobial activity was assessed against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Salmonella enteritidis* according to ISO 22196:2011. Experiments were conducted under laboratory conditions and in practical-use simulations involving reusable water bottles. The tests were performed at 4, 22, and 37°C, reflecting real-life storage conditions. Environmental water samples, including river water, spring water, and melted snow, were also evaluated.The DAT-7 foil exhibited antibacterial activity against all tested microorganisms. The highest susceptibility was observed for *E. coli* and *S. enteritidis*, whereas *B. cereus* showed the greatest resistance. The effectiveness of bacterial inactivation increased with both exposure time and temperature, reaching the highest levels at 22–37°C. In environmental water samples, microbial reductions of approximately 99.99% in river water, 99.96% in spring water, and 99.7% in melted snow were achieved. Lower efficacy observed under practical-use conditions indicates the need for further optimization, particularly by increasing the ratio of active surface area to water volume. DAT-7 foil coated with REDOX represents a promising, simple, and cost-effective solution for improving the microbiological safety of drinking water. The technology shows potential for application in everyday use as well as in regions with limited access to safe drinking water resources.

Keywords: microbiological safety, oxide coatings, antibacterial properties, water treatment.

COMPOST LEACHATES AS A POTENTIAL PATHWAY FOR MICROPLASTIC RELEASE INTO THE ENVIRONMENT

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Biowaste composting is one of the key elements of the circular economy, enabling the recovery of organic matter and its reuse in the soil environment. At the same time, increasing attention is being paid to the potential introduction of polymer contaminants originating from municipal waste into composts, including micro- and nanoplastics.
The aim of this study was to identify and characterize micro- and nanoplastic particles present in aqueous leachates obtained from selected composts.
Dynamic Light Scattering (DLS) was used to determine particle size distribution, while Fourier Transform Infrared Spectroscopy (FT-IR) was applied for the preliminary identification of polymeric materials. The obtained results indicated the presence of particles ranging in size from several tens to several hundreds of nanometers and confirmed the occurrence of spectral signals characteristic of selected plastic polymers.
The conducted research suggests that biowaste-derived composts may constitute a potential pathway for the transfer of micro- and nanoplastics into the soil environment.
Further studies are necessary to assess the scale of this phenomenon and its impact on compost quality and the environmental safety of compost application.
Biowaste compost; micro- and nanoplastics; FT-IR spectroscopy.

FROM REGOLITH TO RESOURCE: EVALUATING THE TOXICITY OF LUNAR AND MARTIAN SIMULANTS

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Space exploration has recently reached new heights, with a lunar orbital mission as recent as April 2026. These missions are precursors to eventual missions to Mars and have ignited renewed global interest in a sustainable human presence beyond Earth. Bioregenerative life-support systems are currently used in space to provide food, water, oxygen, and waste management for astronauts. These systems rely heavily on terrestrial restocking and can therefore benefit from the use of *in situ* resources. One particularly beneficial resource is planetary regolith, which can be used as a substrate for food production. Planetary regolith is not readily available on Earth, and regolith simulants have been designed for research purposes to mimic the physical and chemical properties of actual planetary regolith. To ensure the beneficial utilisation of planetary regolith, a full toxicological profile of the simulants is essential. Therefore, the aim of this study was to determine the toxicological profile of lunar (LHS-1) and Martian (MGS-1) regolith simulants using a battery of in vivo assays representative of different trophic levels and exposure pathways. The test organisms included *Aliivibrio fischeri*, *Daphnia magna*, *Heterocypris incongruens*, *Eisenia andrei*, and the higher plants *Lepidium sativum*, *Sinapis alba*, and *Sorghum saccharatum*. The assays showed that the aqueous extracts exhibited little to no toxicity for either regolith simulant. In contrast, the direct-contact assays revealed significant toxicity in all organisms exposed to ≥ 60% MGS-1. LHS-1 was significantly less toxic overall; however, the simulant was toxic at higher concentrations to *H. incongruens* and *E. andrei*.

IMPACT OF MODIFIED DIGESTATE FROM THE ANAEROBIC DIGESTION PROCESS ON THE PHYSIOLOGICAL STATUS OF TRITICALE (× *TRITICOSECALE* WITTM.) CULTIVATED FOR ENERGY PURPOSES

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The expansion of anaerobic digestion technologies has resulted in an increasing production of digestate, whose effective management represents an important environmental challenge. The utilization of digestate as a fertilizer for energy crops may support nutrient recycling, reduce the demand for mineral fertilizers, and contribute to sustainable biomass production within the circular economy framework. The aim of this study was to evaluate the effect of modified digestate derived from the anaerobic digestion of swine manure on the physiological status of triticale (× *Triticosecale*) cultivated for energy purposes. A pot experiment was conducted using digestate modified with a calcium-based sorbent and dried at different temperatures (40, 60, and 80°C). The digestate was applied with sorbent addition ratios of 1:1, 1:2, and 1:3 (digestate). The physiological response of plants was assessed based on relative chlorophyll content, chlorophyll fluorescence parameters, including maximum quantum yield of photosystem II (F_v/F_m), efficiency of the oxygen-evolving complex (F_v/F_o), and performance index (PI), as well as gas exchange parameters. The results obtained were statistically analyzed to determine the significance of differences between experimental variants. The drying temperature of digestate significantly affected the physiological performance of triticale plants. Digestate dried at 40°C resulted in lower values of most analyzed parameters compared with the control treatment. In contrast, the application of digestate dried at 80°C stimulated photosynthetic activity, increasing net photosynthetic rate (P_N), stomatal conductance (g_s), and transpiration rate (E). No significant effect of digestate application on intercellular CO_2 concentration (Ci) was observed. Appropriately processed digestate may represent an effective fertilizer supporting the production of energy biomass and an environmentally sustainable approach for the management of residues generated during anaerobic digestion. Drying temperature is an important factor determining the agronomic potential of digestate and its impact on plant physiological processes.

Keywords: digestate; anaerobic digestion; energy crops; triticale; photosynthesis

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SOYBEAN RESPONSE TO VERMICOMPOST FERTILIZATION

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The study evaluated the effects of vermicompost fertilization on the growth, physiological performance, yield, and seed quality of soybean (*Glycine max* - Merr.), with particular emphasis on vermicomposts produced from sewage sludge and garden waste as sustainable alternatives to mineral fertilizers. A pot experiment conducted under controlled conditions included four treatments: (I) control, (II) vermicompost produced from 70% sewage sludge and 30% sawdust, (III) vermicompost produced from 70% garden and park waste and 30% sawdust, and (IV) vermicompost produced from 35% sewage sludge, 35% garden and park waste, and 30% sawdust. The evaluated parameters included SPAD values (Soil Plant Analysis Development), chlorophyll fluorescence parameters (Fv/Fm, Fv/F0, PI, and RC/ABS), plant height, the number of pods and seeds, thousand-seed weight, root nodulation, seed yield, and seed protein content. All vermicompost treatments improved the nutritional status and photosynthetic performance of soybean plants compared with the control, as reflected by higher SPAD values and more favorable chlorophyll fluorescence parameters. The greatest benefits were observed with the sewage sludge-based vermicompost, likely due to its higher concentrations of nitrogen, phosphorus, and micronutrients. Vermicompost application significantly increased plant height, the number of pods, the number of seeds per pod, thousand-seed weight, seed yield, and seed protein content. In addition, it enhanced soil fertility by increasing organic matter content and nutrient availability. Overall, vermicompost, particularly that derived from sewage sludge, proved to be an effective and environmentally sustainable fertilizer that improved soybean growth, productivity, and seed quality. Its use offers a promising strategy for reducing reliance on mineral fertilizers while maintaining high crop performance. Further field studies are needed to confirm these findings under practical agricultural conditions.

Keywords: soybean, vermicompost, physiological measurements, yield components, protein

WASTE ALGAL BIOMASS AND COMBUSTION ASH: CHARACTERIZATION AND APPLICATION POTENTIAL

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Waste algal biomass generated during eutrophication and the natural self-purification of aquatic ecosystems represents both an environmental burden and a potentially valuable secondary resource. Owing to its chemical, mineralogical, and surface properties, this material may be suitable for environmental and technological applications. The aim of this study was to characterize waste algal biomass and the products obtained after its thermal conversion in terms of chemical and mineral composition, surface properties, heavy metal content and leachability, sorption performance, and potential use as precursors or additives for functional materials. The collected biomass, consisting predominantly of freshwater filamentous algae, was subjected to thermal conversion in a laboratory-scale installation designed to simulate fluidized-bed combustion conditions. Raw biomass, the resulting ash, and products obtained after ash leaching were analyzed using scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), Brunauer-Emmett-Teller (BET) surface area analysis, and sorption experiments. Heavy metal concentrations and their leachability were also determined. The results showed that both the raw biomass and its combustion-derived products contained heavy metals at concentrations comparable to those reported for similar materials, whereas the leaching of Cd, Cu, Mn, Ni, Pb, and Zn remained limited. FT-IR analysis of the raw biomass identified O-H, CH_2, CH_3, N-H, and O-C-O functional groups, confirming the presence of proteins, lipids, and carbohydrates and indicating favorable conditions for contaminant binding. Raw algal biomass exhibited the highest methylene blue removal efficiency, which was attributed to the abundance of surface functional groups, while the combustion ash retained considerable sorption capacity. The laboratory leaching treatment substantially modified the chemical and mineral composition of the ash. It selectively removed readily soluble alkali-bearing phases, promoted the formation and crystallization of gypsum, and increased the relative contribution of less soluble calcium-bearing phases, including calcium phosphates. The treatment also increased the amount of water-extractable chromium, indicating enhanced mobility of at least part of the chromium present in the material. The combustion ash showed promising potential as a precursor or additive for zeolitic and other functional materials. Overall, waste algal biomass and its processing-derived products constitute promising secondary resources for water treatment, functional material production, and sustainable circular resource management. The results also demonstrate that controlled thermal conversion and subsequent leaching can be used to modify the mineralogical and surface properties of algal biomass ash and thereby influence its potential applications.

Keywords: waste materials, algal biomass, circular economy, functional materials, sorption

References:

Vassilev, S. V., Vassileva, C. G. (2016). Composition, properties, and challenges of algae biomass for biofuel application: An overview. Fuel, 181, 1–33

Vassilev, S. V., Baxter, D. C., Andersen, L. K., Vassileva, C. G. (2010). An overview of the chemical composition of biomass. Fuel, 89(5), 913–933

Werle, S. (2021). Termiczne przetwarzanie biomasy odpadowej jako element gospodarki obiegu zamkniętego. Gliwice: Wydawnictwo Politechniki Śląskiej

Maj, I., Niesporek, K., Płaza, P., Maier, J., Łój, P. (2025). Biomass ash: A review of chemical compositions and management trends. Sustainability, 17(11), 4925

Mirowski, T., Mokrzycki, E., Uliasz-Bocheńczyk, A. (2018). Energetyczne wykorzystanie biomasy. Kraków: Wydawnictwo IGSMiE PAN

CYTOTOXICITY ASSESSMENT OF PET BOTTLE- AND HDPE CAP-DERIVED MICROPLASTICS IN HUMAN KERATINOCYTES

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Growing amounts of plastic waste are leading to its accumulation in the environment, including different aquatic ecosystems [1,2]**.** Physical, chemical, or biological factors contribute to secondary microplastic formation [2]. Environmental microplastic can enter the human body through oral, inhalation, and dermal exposure routes. MPs may affect cell viability, alter gene expression, induce oxidative stress, and activate pro-inflammatory pathways [3]. Although most studies have focused on gastrointestinal exposure, relatively few have investigated the effects of MPs on keratinocytes, structural cells of the epidermis. Polyethylene terephthalate (PET) and high-density polyethylene (HDPE) are common sources of secondary microplastic pollution in water. Despite their widespread occurrence, the effects of PET- and HDPE-derived MPs on human keratinocytes remain poorly understood. The aim of this study was to obtain microplastic from plastic bottles (PET) and caps (HDPE) and to evaluate their potential cytotoxic and cellular effects on the human keratinocyte cell line HaCaT. PET bottles and HDPE caps underwent five grinding steps to obtain microplastic particles. MPs were subsequently characterized using scanning electron microscopy (SEM). HaCaT cells were exposed to different concentrations of PET- and HDPE-derived MPs (10-1000 µg/mL) for 24h. Cell viability was assessed using the alamarBlue assay, with results expressed relative to untreated control. Cell morphology was examined by inverted phase-contrast microscopy. Cell viability remained above 90% at all tested concentrations, well above the 70% threshold commonly used to indicate cytotoxicity. At the highest concentration (1000 µg/mL), viability was 100.72% ± 2.86% and 92.77% ± 3.31% of the untreated control for PET and HDPE MPs, respectively. No changes in cell morphology were observed. PET and HDPE microplastics showed no cytotoxic effects in HaCaT cells after 24h exposure, even at concentrations up to 1000 µg/mL. However, further studies are needed to evaluate potential long-term and subtoxic effects.

Keywords: microplastic, HDPE, PET, cytotoxicity, human keratinocytes

References:

Caputi, S., Diomede, F., Lanuti, P., Marconi, G. D., Di Carlo, P., Sinjari, B., & Trubiani, O. (2022). Microplastics affect the inflammation pathway in human gingival fibroblasts: A study in the Adriatic Sea. International Journal of Environmental Research and Public Health, 19(13), 7782. https://doi.org/10.3390/ijerph19137782.

Giordano, M. E., Lionetto, F., & Lionetto, M. G. (2025). Impact of polyethylene terephthalate nanoplastics (PET) on fibroblasts: A study on NIH-3T3 cells. Frontiers in Physiology, 16, Article 1580682. https://doi.org/10.3389/fphys.2025.1580682.

Chwiej, J., Wytrwal, M., Papacz, K., Jasielczuk I., Wilk A., Gurgul A., Szmatoła T. & Ocłoń E. (2025). Tracing micro and nanoplastics toxicity in human pulmonary fibroblasts through integrated Raman and transcriptomic analyses. Scientific Reports, 15, Article 39459. https://doi.org/10.1038/s41598-025-22947-7.

DIPTERA AS BIOINDICATORS: FROM NATURAL PALEOCLIMATE SHIFTS TO NEXT-GENERATION ANTHROPOGENIC POLLUTION

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The order Diptera constitutes one of the most diverse and evolutionarily plastic insect groups, serving as an exceptional tool for ecological bioindication. The Chironomidae, Syrphidae, and Calliphoridae are most frequently utilized as bioindicators, with certain representatives of Tipulidae, Limoniidae, and Pediciidae being present in both modern fauna and fossil records of various ages. This study evaluates the diagnostic and predictive potential of selected Diptera taxa across distinct temporal scales. Based on both fossil and modern material, this assessment is conducted in the context of climatic shifts throughout different epochs of Earth's history and contemporary anthropogenic stressors. Thereby, a baseline for a comprehensive environmental risk assessment may be established. An interdisciplinary approach was applied, coupling the analysis of fossil assemblages of selected dipteran groups with the biomonitoring of extant populations and taxa recognition using cutting-edge research techniques, including micro-computed tomography (μCT). Selected taxa within Tipulidae and Limoniidae exhibited strict preferences for well-oxygenated, pristine lotic waters, validating their integration into standardized biotic indices such as the Biological Monitoring Working Party (BMWP) systems. Palaeoclimatic reconstructions confirmed the high sensitivity of Diptera to natural, long-term climate oscillations. Concurrently, modern data revealed alarming, highly specific physiological and morphological responses to contaminants of emerging concern (CECs).
Integrating palaeoclimatic baselines with contemporary dipteran-based biomonitoring provides a robust mechanism for forecasting the impacts of current anthropogenic pollution. This holistic framework bridges historical ecological data with modern ecotoxicology, offering an essential tool for proactive environmental protection.

Keywords: Diptera, bioindication, palaeoclimate, paleobiology, environmental monitoring.

REMOVAL OF EMERGING CONTAMINANTS FROM WATER USING ADVANCED OXIDATION PROCESSES

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Bisphenol A (BPA), clopyralid (CLO), and 2,4-dichlorophenoxyacetic acid (24D) were selected as model emerging contaminants (ECs) because of their widespread occurrence in the environment and potential risks to human health and ecosystems. BPA is an endocrine-disrupting compound used in the production of polycarbonate plastics and epoxy resins, whereas CLO and 24D are herbicides frequently detected in surface and groundwater. Since ECs are often resistant to conventional treatment methods, advanced oxidation processes (AOPs), including calcium peroxide-based systems, have attracted increasing attention for water treatment. The main objective of this study was to evaluate the removal efficiency of selected emerging contaminants using calcium peroxide-based advance oxidation processes and to determine the most effective treatment configurations. Calcium peroxide (CaO_2) materials were synthesized using different precursor systems, including calcium carbonate and calcium chloride. Catalytic and photocatalytic degradation experiments were carried out in a laboratory-scale photoreactor under various AOP configurations involving CaO_2, H_2O_2, TiO_2, UV irradiation, and ozone. The degradation of BPA, CLO, and 24D in aqueous solutions was monitored by determining pollutant conversion over time. The investigated AOP systems showed considerably higher efficiency for BPA removal than for CLO and 24D degradation. Among the synthesized oxidants, $CaCO_3$-derived peroxide exhibited the highest activity. The most effective systems for BPA degradation were CaO_2/TiO_2/UV and CaO_2/O_3, with ozonation achieving approximately 96% BPA conversion within 15 minutes. Continuous ozonation combined with CaO_2 significantly improved the degradation of 24D, whereas CLO proved to be the most resistant contaminant under all tested conditions. Calcium peroxide-based AOPs are promising technologies for the removal of emerging organic contaminants from water. Their efficiency can be significantly enhanced by combining CaO_2 with UV irradiation, TiO_2 photocatalysis, or ozonation, offering potential applications in advanced water treatment systems.

Keywords: emerging contaminants, bisphenol A, clopyralid, advanced oxidation processes, calcium peroxide

OPTIMIZATION OF PROCEDURES FOR EXTRACTING SELECTED EMERGING CONTAMINANTS FROM HONEY USING THE MICRO-SPIN SPE TECHNIQUE

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Emerging contaminants (ECs), such as bisphenol A (BPA), clopyralid (CLO), and 2,4-dichlorophenoxyacetic acid (24D), are increasingly detected in environmental and food samples, raising concerns due to their persistence and potential adverse effects on human health and ecosystems. Reliable determination of these compounds requires efficient sample preparation, particularly for complex food matrices such as honey. Solid-phase extraction (SPE) is one of the most widely used techniques for isolating and preconcentrating trace contaminants prior to chromatographic analysis.

The aim of this study was to compare conventional vacuum SPE and micro-spin SPE (µSPE) for the extraction of selected emerging contaminants from aqueous solutions and honey samples and to evaluate the applicability of the micro-spin approach for routine sample preparation.

Water and honey samples were spiked with BPA, CLO, and 24D and extracted using optimized conventional SPE and micro-spin SPE procedures. The obtained extracts were analyzed by high-performance liquid chromatography (HPLC), and the extraction efficiency was assessed based on analyte recoveries.

Conventional SPE provided higher extraction efficiencies than the micro-spin technique for all investigated contaminants. Among the analyzed compounds, BPA exhibited the highest recoveries, whereas CLO showed the lowest affinity toward the extraction sorbents. No adverse effect of the honey matrix on extraction efficiency was observed compared with aqueous solutions. Despite its lower recoveries, the micro-spin SPE technique considerably reduced sample preparation time, solvent consumption, and overall analytical costs.

Conventional SPE remains the more effective approach for extracting the investigated emerging contaminants, while micro-spin SPE offers a rapid, cost-effective, and environmentally friendly alternative for sample preparation. Further optimization of micro-spin technology may improve its extraction performance and broaden its applicability for the determination of emerging contaminants in complex food matrices.

Keywords: emerging contaminant, bisphenol A, clopyralid, solid phase extraction, honey

BACTERIOPHAGES AS BIOINDICATORS OF FECAL POLLUTION AND ENVIRONMENTAL RISK IN THE WISŁOK RIVER

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The monitoring of fecal pollution in surface waters relies heavily on traditional bacterial indicators, which are often prove inadequate due to rapid inactivation and an inability to distinguish between recent and past pollution. This study evaluated somatic coliphages (using *E. coli* ATCC 13706 and CN13 hosts) and F-specific RNA bacteriophages (using the *E. coli* F-amp host) as robust alternative indicators of anthropogenic contamination in the Wisłok River in Rzeszów, south-east Poland. Water samples were collected between July and September 2025 from three locations reflecting different levels of human activity. The results revealed significant spatial and temporal fluctuations throughout the summer. The highest microbiological contamination occurred in July, showing a sharp cumulative trend from upstream to downstream. Somatic coliphages (mean 2,340 PFU/100 ml) and F-specific phages (mean 110 PFU/100 ml) peaked concurrently downstream of the wastewater treatment plant, confirming an influx of fresh fecal pollution. In August, elevated water temperatures shifted the dynamics towards older, diffuse pollution at the upstream sites. By September, hydrological shifts had led to the complete elimination of F-specific phages at all sites, leaving only a residual somatic coliphage background, which indicated that recent inputs were fading. Furthermore, the isolated phages exhibited high phenotypic heterogeneity, forming plaques up to 9 mm in diameter with halo zones, as well as wide thermal stability and robust lytic activity across a broad pH range (4–10). Notably, F-specific phages were more sensitive than somatic coliphages to acidic (below 3) and alkaline (above 11) conditions. This validates their use in assessing the freshness of wastewater discharges. The study demonstrates that integrating somatic and F-specific bacteriophage tracking provides a highly sensitive, low-cost tool for distinguishing between recent and past pollution events, offering a powerful approach for real-time epidemiological surveillance and catchment management.

Keywords: bacteriophages, somatic coliphages, F-specific RNA phages, Wisłok River, environmental monitoring, fecal contamination.

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ASSESSMENT OF THE IMPACT OF SOLID RESIDUES FROM WASTE INCINERATION ON THE SOIL AND WATER ENVIRONMENT

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Waste thermal treatment is one of the key waste management methods, enabling both energy recovery and a reduction in the amount of waste disposed of in landfills. In Poland, thermal treatment facilities operate primarily through the incineration of municipal waste, hazardous waste, including medical waste, and sewage sludge. At the same time, new facilities are under construction, while the district heating sector is preparing for the wider use of alternative fuels derived from waste. As this sector continues to expand, the proper management of solid residues generated during the thermal treatment process is becoming increasingly important.
The thermal treatment of waste generates electricity and heat; however, it also produces significant quantities of solid residues, including bottom ash, fly ash, and air pollution control (APC) residues generated during flue gas cleaning. The physicochemical properties of these materials depend on the type of waste treated, the combustion technology employed, and the flue gas cleaning system, all of which influence their potential for further utilization.
The aim of this study is to evaluate the chemical composition and potential environmental impact of solid residues generated during the thermal treatment of different types of waste. The presentation will discuss the results of chemical characterization and leaching tests performed on the investigated residues. The findings reveal considerable differences in the properties of the examined materials. In many cases, elevated concentrations of chlorides, sulphates, and heavy metals, as well as high leaching of these constituents, were observed. The measured values exceeded the regulatory limits for wastewater discharged to surface waters or soil and the environmental criteria applied in soil quality assessment. The results indicate that leaching behaviour should be considered one of the key parameters in assessing the suitability of solid residues for further management. The study provides valuable information for environmental risk assessment and supports the development of safe strategies for the utilization and management of these waste.

Keywords: waste thermal treatment, solid residues, recovery, soil and water environment, environmental risk

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EFFICIENT REMOVAL OF MICROPLASTICS THROUGH MAGNETITE-INDUCED HETEROAGGREGATION

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Microplastics represent an emerging environmental challenge due to their persistence, small particle size, and resistance to conventional water treatment processes. The development of effective removal technologies is therefore essential to reduce their transport and accumulation in aquatic environments. The aim of this study was to evaluate the efficiency of magnetite-induced heteroaggregation for the removal of different types of microplastics and to identify the operational parameters governing the aggregation process. Laboratory experiments were performed using microplastics differing in polymer type and morphology. The influence of contact time, pH, and magnetite dose on removal efficiency was investigated. Scanning electron microscopy (SEM) was employed to characterize the morphology of the formed heteroaggregates, while Fourier-transform infrared spectroscopy (FTIR) was used to assess possible changes in the chemical structure of the polymers. Statistical analyses together with regression and machine-learning models were applied to identify the most influential process variables and evaluate predictive performance. Magnetite promoted rapid formation of stable heteroaggregates, resulting in high microplastic removal efficiencies under the investigated experimental conditions. SEM observations confirmed effective attachment of magnetite particles to microplastic surfaces, whereas FTIR analysis indicated that aggregation occurred without detectable chemical modification of the polymer structure. Statistical and machine learning analyses demonstrated that contact time, pH, and polymer type were the dominant factors controlling removal efficiency. The obtained results demonstrate that magnetite-induced heteroaggregation is an effective approach for microplastic removal from aqueous systems. The combination of experimental characterization and predictive modelling provides valuable insight into the mechanisms governing the process and supports the optimization of treatment conditions for future water purification applications.

Keywords: microplastics, magnetite, heteroaggregation, machine learning, prediction

ECOTOXICITY OF NANO-TIO_2 IN COMBINATION WITH ESSENTIAL OILS

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Nanomaterials as TiO_2 and essential oils are a part of many human products as cosmetics, drugs or coatings. They involve into environment individually or in mixtures, but their combination in water can lead to some negative interactions with living organisms including freshwater algae and cyanobacteria. These organisms belongs to primarily producents and play an important role in aquatic ecosystems. The aim of the present study was test ecotoxicity of nano-TiO_2 in combination with selected essential oils and discuss the results with available data from our previously published data on individual essential oils The nano-TiO_2 was test separately or in combination with essential oils in aquatic tests under laboratory defined conditions for 14 days. Seven essential oils were tested. One cyanobacteria and four algae species were used as model organisms. The measured endpoint was biomass of organisms. The biomass was measured by spectrophotometer at 750 nm of wavelength at the end of the tests. The absorbance values were overcalculated on inhibition in comparison to control and evaluated by non-parametric statistical method. The results indicate different sensitivity of individual species and variable ecotoxicity. The cyanobacterial species was more sensitive than green algae. The most frequently toxic essential oil was thymol. Nano-TiO_2 as an individual chemical was not toxic to algae and cyanobacteria within tested concentrations. The combination of nano-TiO_2 with some essential oils lead to the different ecotoxicity in comparison to effects of individually tested nano-TiO_2 or the same essential oils in the previous research. It indicate that combination of many chemicals in preparations or their following interactions in waters can lead to a potential ecological risk. The other more detailed research is needed for the understanding of the combine effects of the contaminants. This research was funded by the Czech Science Foundation, project No. 24-10395S.

Keywords: nano-TIO_2, ecotoxicity, algae, cyanobacteria, essential oils

FROM STRESS TO ADAPTATION: THE RESPONSE OF AN ACTIVATED SLUDGE SYSTEM TO AN IRREGULAR INFLOW OF SPECIFIC POLLUTANTS

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Biological wastewater treatment systems are complex ecological structures whose efficiency depends on the ability of activated sludge microorganisms to adapt to changing environmental conditions. One of the most important stress factors affecting these systems is the irregular inflow of wastewater and the periodic presence of potentially toxic compounds. This issue is especially relevant in municipal treatment plants receiving industrial effluents, where fluctuations in wastewater quantity and quality may disrupt biological treatment processes.
The aim of this study was to evaluate the impact of environmental stress resulting from hydraulic and qualitative variability of influent wastewater on the performance of a municipal biological wastewater treatment plant serving an area with a significant share of chemical industry. The analysis covered operational data collected between 2017 and 2025, including wastewater flow rates and concentrations of selected pollutants in raw and treated wastewater. Particular attention was given to formaldehyde, phenolic compounds, zinc, trichloroethylene, and trichloromethane due to their potential toxicity to activated sludge microorganisms.
The results revealed considerable irregularities in wastewater inflow, with flow irregularity coefficients ranging from 1.12 to 1.29. High variability was also observed in the concentrations and loads of specific pollutants, with coefficients of variation frequently exceeding 100%, indicating the occurrence of short-term pollutant load pulses. The greatest fluctuations were recorded for organohalogen compounds and phenols, reflecting periodic discharges of industrial wastewater.
Despite exposure to multiple environmental stressors, including hydraulic overloads, sudden changes in wastewater composition, and the presence of toxic substances, the biological treatment system demonstrated high resistance and adaptability. The treatment plant maintained effective removal of all analysed pollutants, and their concentrations in the treated effluent remained below regulatory limits. These findings indicate that the ability of activated sludge microorganisms to respond to periodic disturbances is a key factor determining process stability and the resilience of wastewater treatment systems under anthropogenic pressure.

Key words: environmental stress, biological response, activated sludge, specific pollutants, domestic and industrial wastewater, resilience of technological ecosystems

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EMERGING CONTAMINANTS IN LANDFILL LEACHATE: POTENTIAL EFFECTS ON BIOLOGICAL WASTEWATER TREATMENT PROCESSES

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Leachate from the landfilling of household waste is a complex mixture of organic and inorganic contaminants, including also pharmaceuticals, personal care products, endocrine-disrupting compounds, pesticides, and per- and polyfluoroalkyl substances (PFAS).These micropollutants can enter wastewater treatment plants via this route and affect biological treatment processes, even at low concentrations. Toxic or inhibitory effects on activated sludge can compromise treatment performance, resulting in an overall efficiency reduction. This study presents the current state of knowledge on the occurrence of micropollutants in municipal LL and their potential impact on activated sludge activity assessed by the oxygen uptake rate (OUR). Review of available studies indicates that the above-mentioned micropollutants can significantly modify activated sludge respiratory activity. Pharmaceuticals such as diclofenac, ibuprofen, carbamazepine, and sulfamethoxazole have frequently been associated with inhibitory effects on microbial activity and reduced biodegradation efficiency. Adverse impacts have also been reported for endocrine-disrupting compounds, including bisphenol A (BPA), and antimicrobial personal care product ingredients such as triclosan. Furthermore, growing concern surrounds PFAS, whose environmental persistence may alter microbial community composition and reduce the final efficiency of treatment. The extent of negative effects depends on the nature and concentration of individual compounds, mutual interactions in complex mixtures, and the adaptive capabilities of activated sludge organisms. Among the other methods, OUR appears to be a useful indicator for evaluating biological system response under technological conditions, practically supporting the assessment of risks associated with landfill leachate co-treatment in wastewater treatment plants.

Keywords: landfill leachate, oxygen uptake rate (OUR), micropollutants, biological wastewater treatment

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INTERNALIZATION AND RESILIENCE TO THE MICROPLASTIC PARTICLES IN SELECTED PLANT SPECIES

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Microplastics (MPs) has emerged as one of the major environmental challenges of the 21st century. These particles are highly persistent and accumulate in ecosystems. Recent studies prove that they also enter plant tissues, potentially affecting plant growth, physiology, and food safety. We aimed to examine the effect of three types of microplastics on seed germination, seedling growth, and cell viability in two cultivated species (*Fagopyrum esculentum*, *Lepidium sativum*) and one heavy metal–tolerant species (*Arabidopsis arenosa*). Seeds of all species were grown on a solid medium containing polystyrene; unmodified (N), and fluorochrome-labeled modified with amino or sulfate groups (A and S), all at concentrations of 500 µg/L and 1,000 µg/L under seven-day phytotoxicity test conditions. Suspended cells of *A. arenosa* grown in liquid medium were treated with 100 or 500 µg/L of the same MPs for 3 days and their viability was measured by alamarBlue. The presence of microplastics in cells and tissues was evaluated using fluorescence microscopy, scanning electron microscopy, and Raman spectroscopy. Seed germination was largely resilient to microplastic stress, with success primarily driven by species-specific ontogeny. However, subsequent root elongation exhibited divergent physiological responses. While a concentration of 1,000 µg/L served as a physiological tipping point inducing growth inhibition in sensitive taxa like *F. esculentum*, others such as *L. sativum* maintained developmental stability. At the cellular level, *A. arenosa* exhibited remarkable resilience; exposure to MPs did not compromise viability and in the case of S particles, triggered a robust hormetic response, increasing cell viability. Crucially, polystyrene accumulation was confirmed across all species, predominantly localized in roots, particularly in root hairs and vascular tissues. Plant responses to MPs are driven by physiological tolerance and accumulation rather than exclusion. Despite internal uptake, plants show high resilience and can accumulate microplastics without visible toxicity.

Keywords: polystyrene, root growth, cell viability, Raman spectroscopy, scanning electron microscopy

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ASSESSMENT OF HEAVY METAL CONCENTRATIONS IN PM2.5 AIRBORNE PARTICULATE MATTER IN RZESZÓW, POLAND

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Airborne particulate matter is recognized as one of the major environmental factors affecting human health due to its ability to transport toxic trace metals. Urban and industrial activities contribute significantly to the accumulation of heavy metals in atmospheric aerosols, increasing the risk of respiratory and cardiovascular diseases. Monitoring the elemental composition of PM2.5 is therefore essential for assessing air quality and potential health hazards. **Aim:** The aim of this study was to determine selected heavy metal concentrations in PM2.5 airborne particulate matter collected in Rzeszów, Poland, and to evaluate the occurrence of potentially toxic elements associated with urban air pollution. PM2.5 samples were collected using air particulate matter samplers in Rzeszów. The collected filters were subjected to acid mineralization using a Microwave Digestion System M3 (PreeKem Scientific Instruments, China). Quantitative analysis of selected metals, including Cr, Ni, Zn, As, Cd, and Pb, was performed using inductively coupled plasma mass spectrometry (ICP-MS) 7850 ICP-MS (Agilent Technologies, USA). Among the analyzed elements, Zn and Pb showed the highest concentrations in PM2.5 samples, indicating a strong influence of traffic emissions and urban anthropogenic activity. Elevated concentrations of Cr and Ni were also observed, suggesting contributions from industrial and combustion-related sources. Toxic trace elements such as As and Cd were detected at lower concentrations but remain important due to their high toxicological relevance. The study confirmed the presence of toxic heavy metals in PM2.5 particulate matter in Rzeszów, highlighting the impact of urban emissions on air quality. Continuous monitoring of heavy metals in air is necessary to better assess environmental exposure and potential health risks for the local population.

Keywords: PM2.5, heavy metals, ICP-MS, air pollution

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POLLUTIONS LEGACIES OF WAR: LONG TERM CONSEQUENCES

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Ongoing armed conflicts have intensified concerns about warfare-related environmental contamination. The aim of this study was to summarize the current state of knowledge based on dispersed publications and to highlight the impact of the evolving nature of warfare on the emergence of new types of environmental contaminants and their environmental impact. A review of over 1,300 publications identified 130 relevant studies. Based on these studies, the following categories of contaminants were identified and used to synthesize the current state of knowledge: heavy metals, explosive materials, chemical warfare agents, dioxins and other organic compounds associated with industrial production of military products or generated by bombardment, as well as hydrocarbons and depleted uranium. Emerging military contaminants, such as microplastics and pollutants associated with unmanned aerial vehicles (UAVs) were highlighted as a research gap. The analysis demonstrated that advances in military technology have led to the introduction of successive classes of contaminants into the terrestrial and marine environments, many of which may persist for decades. Illustrative examples include the long-term legacy of the First World War, particularly the issue of dumped chemical weapons; the presence of TCDD as a remnant of the Vietnam War; and contamination associated with depleted uranium and hydrocarbons during the 1991 Gulf War and the conflicts in the former Yugoslavia. In 2025 alone, Russia deployed more than 50,000 Shahed-type drones in the Russia-Ukraine war, generating debris-derived composite pollutants. Based on these findings, it was concluded that the environmental consequences of warfare are systemic and long-term in nature, constituting a phenomenon of global scale. They affect a wide range of locations, from historical battlefields and military training grounds to munitions storage and disposal sites. These often-overlooked contamination sites require systematic environmental monitoring and harmonized global analytical methods.

Keywords: warfare pollution, environmental legacy, military contamination, chemical warfare agents, energetic compounds

NON-NATIVE SPECIES OF URBANISED AREAS - CHECKLIST. THE CASE OF RZESZÓW, SE POLAND

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Progressive urbanization, which is considered to be the crucial environmental transformation of anthropogenic character, poses one of the most significant threats to the biological diversity of many ecosystems. Not only does it lead to habitat fragmentation and isolation, and it also contributes to the enhancement of the "urban heat island" effect. This results in an influx and synurbization of alien (invasive) species, including numerous phytophages.

Thus far, 19 species of alien insects have been recorded in Rzeszów therein 3 species of Hymenoptera order: *Sceliphron curvatum* Smith, 1870 (Sphecidae), *Sceliphron destillatorium* Illiger, 1807 (Sphecidae), *Steffanolampus salicetum* Steffan, 1952 (Perilampidae); 5 species of Coleoptera order: *Lamprodila festiva,* Linnaeus, 1767 (Buprestidae), *Harmonia axyridis* Pallas, 1773 (Coccinellidae), *Leptinotarsa decemlineata* Say, 1824 (Chrysomelidae), *Diabrotica virgifera virgifera* Le Conte, 1868 (Chrysomelidae), *Stelidota geminata* Say, 1825 (Nitidulidae); 5 species of Lepidoptera order: *Argyresthia thuiella* Packard, 1871 (Argyresthiidae), *Cameraria ohridella* Deschka & Dimić, 1986 (Gracillariidae), *Phyllonorycter issikii* Kumata, 1963 (Gracillariidae), *Phyllonorycter robiniella* Clemens, 1859 (Gracillariidae), *Cydalima perspectalis* Walker 1859 (Crambidae); 6 species of Hemiptera order: *Cinara curvipes* Patch, 1912 (Aphididae), *Stictocephala bisonia* Kopp & Yonke, 1977 (Membracidae), *Corythucha ciliata* Say, 1832 (Tingidae), *Corythucha arcuata* Say, 1832 (Tingidae), *Leptoglossus occidentalis* Heidemann, 1910 (Coreidae), *Oxycarenus lavaterae* Fabricius, 1787 (Lygaeidae).

Key words: alien species, invasive species, biodiversity, urbanization

MICROPLASTICS SEPARATION FROM SOIL MATRIX – CHALLENGES AND PERSPECTIVES

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Microplastics (MPs), commonly defined as plastic particles ranging from 1 μm to 5 mm in size, pose a potential threat to terrestrial and aquatic ecosystems. Although increasing attention has recently been given to their occurrence in soils, their reliable extraction from complex soil matrices remains a substantial methodological challenge. This study aimed to (i) evaluate a commonly used method for separating microplastics from the soil matrix, (ii) identify the main methodological challenges encountered during the procedure, and (iii) propose potential improvements to the method. Microplastics were extracted from 50 g soil samples using organic matter digestion followed by density separation. The digestion procedure involved adding 20 mL of 0.05 M $FeSO_4 \cdot 7H_2O$, 1.5 mL of concentrated H_2SO_4, and 20 mL of 30% H_2O_2. After digestion, the samples were rinsed and transferred to Erlenmeyer flasks. A $ZnCl_2$ solution with a density of 1.7 g cm^{-3} was then added, and the suspensions were stirred and left to settle for at least 24 h. The floating fraction was subsequently decanted into a clean flask. The recovered suspensions were passed through 100 μm sieves, reflecting the lower particle-size limit adopted for subsequent μATR-FTIR identification, and rinsed with water. The isolated MPs particles were collected on membrane filters using vacuum filtration and stored in glass Petri dishes until analysis. It was found that digesting organic matter before density separation was essential to disrupt soil aggregates in which microplastics could be physically entrapped. In samples with high organic matter content, the digestion stage had to be extended and required repeated additions of H_2O_2, pH adjustments, and external ice cooling to control rapid temperature increases due to exothermic oxidation. During density separation, optimization of the $ZnCl_2$ volume was also necessary. Residual lignin- and cellulose-rich material expanded upon contact with the solution, increasing sample volume and creating a risk of material loss. Visual examination and spectroscopic analysis indicated that organic matter could not be completely removed, even after prolonged digestion, thereby interfering with microplastic identification and quantification. Density separation combined with chemical digestion can effectively isolate microplastic particles from soils, but the extent of the methodological challenges encountered strongly depends on the properties of the soil matrix. Persistent organic residues remain a major source of interference and may reduce the accuracy of microplastic quantification. Therefore, the proposed optimization and standardization of digestion procedures are essential for reliable, comparable, and high-throughput monitoring of MPs contamination in soils.

Keywords: microplastics, soil contamination, density separation, organic matter

PFAS IN AGRICULTURAL SOILS OF GALICIA (NW SPAIN): DEVELOPMENT OF AN ADVANCED ANALYTICAL METHODOLOGY

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Per- and polyfluoroalkyl substances (PFAS) form a broad group of over 10,000 compounds known as "forever chemicals" due to the exceptional stability of their carbon-fluorine (C-F) bonds. Their high environmental persistence, mobility, trophic transfer, and potential for bioaccumulation pose significant risks to human health and ecosystems. Recent studies suggest that PFAS can enter agricultural soil through widely used pesticides and herbicides (e.g., flufenacet, flutolanil), organic amendments, and other agricultural inputs, making farmland a potential PFAS sink. However, the structural diversity of these compounds and the complexity of the soil matrix make their detection and quantification highly challenging using conventional chromatographic techniques. This project proposes the development and validation of an advanced analytical methodology based on ultra-high-performance liquid chromatography coupled with high-resolution mass spectrometry using an Orbitrap Exploris 120 analyzer (LC-Orbitrap-HRMS). This platform enables both targeted quantification of known PFAS and the identification of emerging compounds and precursors through suspect and non-target screening — overcoming the limitations of classical triple-quadrupole techniques. Over an 8-month period, the methodology will be optimised and validated against international criteria (LOD, LOQ, precision, accuracy, reproducibility) and then applied to real agricultural soil samples from Galicia (NW Spain). Samples following the LUCAS methodology (a sample of five subpoints at 0–20 cm depth) will be collected from diverse soil types and land uses, considering factors such as crop type, fertilization practices, phytosanitary treatments, and proximity to urban or industrial areas. The results will help establish PFAS distribution patterns, assess links with agrochemical applications, and identify contamination sources. Ultimately, this project aims to build foundational knowledge of PFAS contamination in southern Galicia, supporting a future, larger-scale study that covers a broader range of land-use categories.

Keywords: agricultural soil, emerging pollutants, soil contamination, Orbitrap

ANALYSIS OF THE CONTENT OF ^{210}PO AND URANIUM ISOTOPES IN THE COMPONENTS OF THE POST-MINING ENVIRONMENT IN THE SUDETES

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This paper presents the results of an analysis of uranium and polonium isotope concentrations in plant and soil samples collected from the area of a former uranium mine in Kowary (Sudety Mountains, Poland). The Kowary mining area is characterized by an elevated potential for natural radionuclide occurrence in the environment, which is related to the intensive uranium ore exploitation conducted there in the past. Although several decades have passed since the end of mining operations, the processes of radionuclide migration in the environment, their accumulation in plant organisms, and the potential impact on local biocenoses remain a significant subject of research. Analyzing radionuclide concentrations in environmental components is crucial for assessing the level of contamination, identifying potential ecological threats, and planning remediation and radiological monitoring activities.

The aim of the study was to assess the level of environmental contamination in the area of former uranium mines and to determine the potential for radionuclide bioaccumulation by selected plant species occurring in their immediate vicinity. Plant and soil samples were collected at selected locations at varying distances from historical mining sites. The research material was prepared appropriately, including drying, mineralization, and radiochemical separation of the analyzed isotopes. The determinations were performed using alpha spectrometry.

Based on the obtained alpha spectra, the concentrations of the ^{210}Po, ^{234}U, and ^{238}U isotopes in the analyzed samples were calculated, and the ranges of their highest and lowest values were determined. Additionally, the annual effective doses for adults resulting from potential exposure to the studied radionuclides were estimated. The obtained results allow for an assessment of the presence of natural radionuclides in the post-mining environment and indicate the possibility of using selected plant organisms as bioindicators of radiological contamination.

PLANT IDENTITY SHAPES SOIL CORE MICROBIOMES OF POST-INDUSTRIAL SITES

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Post-coal mine sites are highly disturbed environments characterized by poor nutrient availability and the presence of contaminants. Soil microbial communities play a crucial role in nutrient cycling, plant establishment, and ecosystem recovery in such depleted habitats. To assess the establishment of the plant's native microbiome in spoil heap soil, depending on the introduced plant species, and to test their ecophysiological and morphological responses to growth on said medium. Three plant species: forb *Echium vulgare* L., legume *Lotus corniculatus* L., and grass *Festuca rubr*a L. were selected for this purpose, and grown on sterilized and non-sterilized soil in incubation chambers for 7 weeks, after which time the molecular analyses and plant functional traits measurements were taken. The nonparametric Mann-Whitney U test was used to assess whether the variants differed significantly. Different plant species significantly influenced the establishment and composition of microbial communities in spoil-heap soil. Sterilization of the substrate reduced several physiological parameters, indicating a loss of beneficial plant–microbe interactions that support plant functioning under stressful conditions present on contaminated soils of waste heaps. The strongest plant–microbiome feedbacks were observed for *E. vulgare* and *L. corniculatus*, suggesting that these species may more effectively promote the development of beneficial microbial communities in spoil-heap environments. The results demonstrate that plant functional type influences the development of microbial communities in spoil-heap substrates and, in turn, affects plant performance. These findings suggest that the selection of appropriate functional plant groups may facilitate microbiome establishment and improve the success of restoration and phytostabilization efforts on contaminated post-industrial sites.

Keywords: post-coal mine spoil heaps; post-industrial soil; habitat template approach; plant-associated microorganisms; plant functionality

THE EFFECT OF ENZYMATIC PRETREATMENT ON INCREASING THE SOLUBILITY AND BIODEGRADABILITY OF INSECT BREEDING POST PRODUCTION WASTE

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Insect farming is currently a growing industrial sector focused on the production of larvae, adult insects, and various byproducts that can be used in the production of food for humans and animals. Due to their composition, which includes high amounts of proteins and lipids, they are also used in biofuel production and biorefinery processes. A promising source of energy could be waste from insect farming. There are only a few studies on the production of biogas during their fermentation; however, there are no studies on the potential to increase biodegradability of this type of waste using pretreatment. The aim of the article was to investigate whether enzymatic pretreatment, and at what dosage of cellulase, has an effect on increasing solubility and biodegradability of insects breeding post production waste. Prior to pretreatment, the waste from insect farming was suspended in wastewater after the mechanical treatment stage in a volumetric ratio of 2:1. The pretreatment process was carried out using the enzyme cellulase. First, 2, 4 and 6 g of cellulase were added to 500 ml of the mixture of wastewater and waste. The mixture was then placed at a controlled temperature of 20°C for 24 hours. In the mixture before and after enzymatic pretreatment following parameters were analysed: COD and sCOD, TS and VS, DOC and TOC, phenols, ammonia nitrogen, pH as well as a FT-IR/ATR and fiber analysis. After applying 6g of cellulose the DOC/TOC ratio, increased by 55%. In contrast, the COD value, as well as the concentrations of VS, TS and TOC, decreased, indicating that enzymatic pretreatment effectively breaks down complex organic compounds. The decrease in the content of hemicellulose, cellulose and lignin, accompanied by the release of phenols, indicates that the carbohydrates have been solubilized. The spectral data confirms that the 6g cellulase dose was the most effective in deconstructing the waste matrix, resulting in a significantly depleted solid residue with reduced fiber and protein bands. Enzymatic pretreatment using cellulase can be used for pretreatment this type of waste.

Keywords: enzymatic pretreatment, insect breeding post production waste, cellulase, biodegradability, solubility

MICROPLASTICS IN AGRICULTURAL SOILS OF YOUNG MORAINIC LANDSCAPE – A CASE STUDY FROM CHEŁMNO LAKE DISTRICT (NORTHERN POLAND)

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Microplastic (MPs) pollution is currently one of the most significant environmental issues. However, agricultural areas remain relatively underexplored regarding to the presence and risk associated with plastic microparticles. The aim of presented study is to quantify and characterise the types of MPs occurring in the agricultural soils of young morainic landscape. Ten topsoil (0–30 cm) samples with three replicates, were taken from arable lands in the study area. The extraction of MPs from soils was performed according to method of Liu et al. (2018). Identification of MPs was performed with a PerkinElmer 200i FT-IR microscope equipped with a mid-infrared (MIR) source and a mercury cadmium telluride detector. In all studied samples MPs were present. The predominant types of MPs were polyethylene, primarily derived from a wide variety of packing materials and polyvinyl associated with the operation of agricultural machinery. Other MPs such as a polystyrene or neoprene were also present. Based on our results, it can be concluded that soil contamination of MPs in arable soils in young morainic landscape can be a significant environmental problem that has been overlooked in research so far and further research in that matter are needed.

Keywords: Microplastics, soil pollution, polyethylene, polyvinyl

References:
Liu, M., Lu, S., Song, Y., Lei, L., Hu, J., Lv, W., Zhou, W., Cao, C., Shi, H., Yang, X., He, D., 2018. Microplastic and mesoplastic pollution in farmland soils in suburbs of Shanghai, China. Environmental Pollution 242, 855–862. https://doi.org/10.1016/j.envpol.2018.07.051.

POTENTIAL OPPORTUNITIES AND LIMITATIONS OF SEED NANOPRIMING FOR MITIGATING SOIL SALINIZATION: THE CASE OF GRAPHENE OXIDE NANOPRIMING IN BARLEY (HORDEUM VULGARE)

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The growing human impact on the environment and advancing climate change are contributing to the worsening global problem of soil salinization, threatening natural ecosystems and food security due to the progressive loss of soil suitability for cultivation. One promising way to mitigate salt stress in agriculture is seed nanopriming.

The aim of this study was to investigate the potential protective effect of graphene oxide nanoparticles (GO-NPs) against salt stress symptoms in barley seeds (Hordeum vulgare) and to analyze the implications of implementing this technology in agriculture.

To confirm the effect of salt stress, we first determined that salt stress induced by sodium chloride (NaCl) at concentrations of 150 and 200 mM significantly inhibited seed germination and seedling growth compared to the control group. Various concentrations of graphene oxide nanoparticles were applied in the form of nanopriming in salinity stress conditions in an attempt to reverse these effects. As part of an analysis of the risks and potential benefits associated with the use of nanopriming to mitigate the effects of salt stress in crops under agricultural conditions, a review of the relevant literature was conducted.

The results of our laboratory studies indicate that nanopriming with graphene oxide significantly improves seed germination and the development of barley seedlings under salt stress conditions. At the same time, a review of the relevant literature indicates the need for further, more extensive research on the impact of nanopriming of crop seeds on non-target organisms and on the overall state of the natural environment surrounding farmland.

Based on the results obtained, we have concluded that the development of seed nanopriming technology should be based on a comprehensive environmental impact assessment. Before ready-to-use formulations are introduced to the market, appropriate law regulations should also be put in place to prevent the misuse of this method in agriculture.

Keywords: Nanopriming, Graphene oxide nanoparticles (GO-NPs), Soil salinization, Environmental risk assessment, Germination

ASSESSMENT OF NATURAL AND ARTIFICIAL RADIOACTIVITY IN SOIL SAMPLES FROM THE "KORZENIOWY DÓŁ" EARTHWORM HABITAT IN KAZIMIERZ DOLNY ON THE VISTULA

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The western part of the Lublin Upland has the highest concentration of ravines in Europe. Among them, the "Korzeniowy Dół" Ravine in Kazimierz Dolny stands out as one of the most spectacular loess gorges in Poland, valued for its geotourism potential and its unique system of exposed tree roots. The gorge is bordered at the top by agricultural land, and surface runoff carrying excess fertilizers could raise the natural radioactivity of its soils. No data on soil radioactivity from this site have previously been reported. To assess the environmental and human exposure to ionizing radiation from natural and artificial radionuclides in soils of the "Korzeniowy Dół" gorge. Eight soil samples were collected and analysed by gamma-ray spectrometry to determine the activity concentrations of potassium-40, radium-226, thorium-232 and caesium-137. Radiological hazard parameters were then calculated to evaluate health and environmental risk. Mean activity concentrations were 24.9 for radium-226, 23.8 for thorium-232 and 370 for potassium-40 becquerels per kilogram, all below the corresponding world averages of 35, 30 and 400 becquerels per kilogram. Caesium-137 averaged 1.08 becquerels per kilogram, indicating trace residues from the Chernobyl accident. The mean annual effective external dose was 0.051 millisieverts per year, 26 percent below the world average, while the external hazard index and gamma dose rate averaged 0.24 and 41.8 nanograys per hour, both within reported world averages. The soils of "Korzeniowy Dół" show low natural radioactivity typical of loess regions of south-eastern Poland and pose no threat to people or the environment. The results provide reference data for future environmental monitoring in the Lublin Upland.

Keywords: natural radioactivity, gamma-ray spectrometry, soil; loess, Korzeniowy Dół

HIGHER PLANTS – SELECTING BIOINDICATORS FOR COMPREHENSIVE ENVIRONMENTAL RISK ASSESSMENT

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The reliability of ecotoxicological assessment largely depends on the selection of appropriate test organisms. Because no single species can adequately represent the diversity of environmental contaminants and exposure pathways, modern environmental risk assessment increasingly relies on standardized bioassays employing organisms from different trophic levels and environmental compartments. The integration of complementary bioindicators enables a more comprehensive evaluation of contaminant effects than physicochemical analyses or single-species testing alone.

As a case study, acute phytotoxicity assays using *Spirodela polyrhiza* and *Triticum aestivum* were compared to evaluate the toxicity of landfill leachates toward organisms representing aquatic and terrestrial ecosystems. The study assessed seed germination and early seedling development of *Triticum aestivum*, together with growth inhibition of *Spirodela polyrhiza*, providing insight into the responses of two complementary plant bioindicators.

The comparative evaluation demonstrated that the two species differed in their sensitivity to the same environmental samples, confirming that organism selection substantially influences toxicity assessment. Organisms representing different trophic levels and environmental compartments provide complementary information by responding to distinct biological endpoints and exposure pathways. Consequently, reliance on a single bioassay may underestimate the ecological risks associated with complex contaminant mixtures.

Integrating standardized multi-species bioassays with physicochemical analyses provides a robust and ecologically relevant framework for environmental monitoring and environmental risk assessment.

Keywords: ecotoxicology, bioindicators, environmental risk assessment, multi-species bioassays

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INTEGRATED ASSESSMENT OF LANDFILL LEACHATE REMEDIATION METHODS: FROM POLLUTANT REMOVAL TO TOXICITY REDUCTION

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Landfill leachate remains one of the most challenging waste-derived matrices to manage due to its highly variable composition, elevated concentrations of organic matter, ammoniacal nitrogen, heavy metals, dissolved salts, and numerous emerging contaminants. Leachate characteristics change considerably with landfill age, climatic conditions, and waste composition, making the development of universally effective treatment strategies particularly difficult. Consequently, conventional physicochemical or biological processes often fail to achieve satisfactory removal efficiencies for all contaminant groups while simultaneously reducing environmental toxicity.

This review summarizes current advances in landfill leachate treatment technologies, including biological treatment systems, membrane processes, advanced oxidation processes, coagulation–flocculation, adsorption, and integrated hybrid systems. Particular attention is devoted to biological reactors enhanced with activated carbon, which have gained increasing interest due to their ability to combine microbial degradation with adsorption of refractory organic compounds. Activated carbon provides a large specific surface area that promotes biofilm development, stabilizes microbial communities, and improves the removal of dissolved organic matter, trace organic pollutants, colour, and selected micropollutants. Recent studies indicate that integrating activated carbon into biological treatment systems can significantly improve treatment efficiency while reducing membrane fouling and increasing process stability under variable operating conditions.

Despite considerable technological progress, the reduction of conventional chemical parameters such as COD, BOD, or ammonium does not necessarily correspond to decreased ecological risk. Therefore, increasing attention is being directed toward integrating ecotoxicological assessment with physicochemical monitoring to evaluate the actual environmental safety of treated leachates. The literature indicates that bioassays employing organisms representing different trophic levels provide complementary information on residual toxicity that cannot be identified through chemical analyses alone.

Future research should focus on optimizing hybrid treatment systems that combine high pollutant removal efficiency with verified toxicity reduction, supporting the development of more sustainable and environmentally relevant landfill leachate management strategies.

Keywords: landfill leachate, biological treatment, activated carbon, ecotoxicity, physico-chemical treatment

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FROM PERSONAL CARE TO ENVIRONMENTAL CONCERN: A CRITICAL REVIEW OF EMERGING CONTAMINANTS DERIVED FROM THE COSMETIC INDUSTRY LIFECYCLE

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The cosmetic market represents one of the largest industrial sectors, with its value continuously growing both globally and in Poland. Retail sales of cosmetics in Europe reached €104 billion in 2024, and Poland is the 5th largest market in Europe. This dynamic growth is accompanied by the implementation of new technologies, novel raw materials, and innovative packaging. Throughout their lifecycle—from raw material synthesis to consumer wash-off and municipal wastewater discharge—cosmetics release a broad spectrum of emerging contaminants into the environment. This study aims to critically evaluate the cosmetic product lifecycle by identifying key classes of emerging contaminants, assessing their environmental persistence and wastewater treatment plant removal efficiencies, and determining their ecotoxicological impacts on aquatic ecosystems. A systematic literature review was conducted, analyzing peer-reviewed scientific studies and recent regulatory reports regarding cosmetic-derived pollutants. The investigation covered major chemical groups: UV filters, parabens, siloxanes, PFAS, nanomaterials, and microplastics. Data regarding wastewater treatment plant (WWTP) removal efficiencies, bioaccumulation factors, and toxicological mechanisms were systematically evaluated. The annual production of personal care products leads to the continuous discharge of thousands of tons of chemical compounds into aquatic systems. Many of these substances bypass conventional wastewater treatment barriers, demonstrating environmental persistence, bioaccumulation potential, and the ability to form secondary transformation products of unknown toxicity. Given that the complete market withdrawal of these products is unfeasible, continuous monitoring of high-risk ecotoxicological contaminants and the integration of green chemistry solutions during product formulation are imperative.

Keywords: cosmetics lifecycle, cosmetic products, water pollution, cosmetic-derived pollutants, ecotoxicity

ENVIRONMENTAL RISKS POSED BY PFAS AND STRATEGIES FOR MINIMIZING THEM IN UKRAINE

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Per- and polyfluoroalkyl substances (PFAS) are among the most hazardous persistent organic pollutants due to their exceptional chemical stability and ability to accumulate in aquatic ecosystems and living organisms. Their persistence and bioaccumulation potential necessitate the development of effective technologies for their removal from contaminated water. One promising approach is the use of magnetically responsive carbon adsorbents. To investigate the structural, porous and magnetic properties of magnetically responsive carbon nanocomposites synthesised from wheat straw and to evaluate their potential for the adsorption-based removal of PFAS. The nanocomposites were synthesised by two-stage pyrolysis using iron(III) chloride and nickel chloride as activating agents. Structural characterisation was performed using scanning electron microscopy and X-ray diffraction. The porous structure was analysed from nitrogen adsorption isotherms, while the magnetic properties were determined by vibrating sample magnetometry. Surface characteristics were evaluated by determining the point of zero charge (pH_{PZC}). Iron(III) chloride promoted the intensive development of a microporous structure, whereas nickel chloride facilitated the formation of nanocomposites with superior magnetic properties. Depending on the activating agent, magnetite or nickel nanoparticles were formed within the carbon matrix. The nickel-based nanocomposite proved to be the most promising material for PFAS removal, exhibiting a high pH_{PZC} value (9.28), which favours electrostatic attraction of anionic PFAS species under typical natural water conditions. The synthesised magnetically responsive carbon nanocomposites combine a well-developed porous structure, favourable magnetic properties and appropriate surface characteristics. The nickel-modified nanocomposite is the most promising adsorbent for PFAS removal from water owing to its high adsorption efficiency and the possibility of rapid magnetic separation after the treatment process.

SEASONAL VARIATION OF SOIL MICROBIOMES AS A TOOL FOR IDENTIFYING POTENTIAL INDICATOR MICROORGANISMS IN ENVIRONMENTS EXPOSED TO CHEMICAL CONTAMINATION

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Soil contamination represents a growing threat to ecosystems and public health. In response to these challenges, the Mobiles project aims to develop advanced biosensors for the detection of selected organic pollutants. An important component of the project is the characterization of soil microbiomes from environments exposed to various chemical contaminants. In this study, the taxonomic diversity of microorganisms present in soil samples collected in the countries participating in the project was analyzed. Particular attention was given to the comparison of samples collected during two research seasons — spring and autumn. Sequencing data were used to perform metataxonomic analyses, including the assessment of alpha and beta diversity, taxonomic profiling, core microbiome analysis, and the identification of taxa differentiating the studied locations and seasons. The results revealed differences in the composition of microbial communities between the analyzed locations, as well as seasonal changes in the structure of soil microbiomes. Alpha diversity indicated differences in taxonomic richness, whereas beta diversity analysis enabled the assessment of microbiome similarity between sites and seasons. Core microbiome analysis allowed the identification of a group of taxa shared across the studied samples. In turn, differential abundance analysis enabled the identification of taxa whose relative abundance changed significantly between locations or seasons. The study highlights the importance of metataxonomic analyses in assessing the impact of chemical contaminants on soil microbiomes.

Keywords: soil microbiome, chemical contamination, seasonal variation, indicator microorganisms, metataxonomics

IN VITRO ASSESSMENT OF THE ANTIBACTERIAL EFFICACY OF ASCORBIC ACID AGAINST MULTI-DRUG RESISTANT PATHOGENS

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The escalating crisis of antimicrobial resistance (AMR) necessitates systematic evaluation of unconventional antimicrobial agents. Ascorbic acid has long been reported to inhibit bacterial growth, yet published minimum inhibitory concentrations span several orders of magnitude, and studies rarely control for the contribution of medium acidification or account for the chemical form of the compound.

To characterise the concentration-dependent antibacterial activity of ascorbic acid against selected multi-drug resistant pathogens in a rich growth medium, and to assess to what extent the observed effect can be attributed to acidification alone.

Multi-drug resistant reference strains representing Gram-negative and Gram-positive pathogens were exposed to a range of ascorbic acid concentrations in a rich broth medium at a defined inoculum density. Growth was monitored by continuous spectrophotometric measurement over an extended incubation period, with biological replication. Parallel acid controls, prepared by adjusting the medium with hydrochloric acid to pH values matching those of the corresponding ascorbic acid solutions, were included to discriminate between the effect of the compound and that of acidification. Terminal spot plating was performed to assess recovery on solid medium.

Ascorbic acid inhibited growth in a concentration-dependent manner, with thresholds differing between species. The acid controls proved discriminating and indicate that the observed effect is not attributable to acidification alone across the panel, although the relative contribution of pH appears to be species-dependent. Marked divergence between replicates was observed at concentrations close to the inhibitory threshold. Detailed thresholds, kinetic profiles and recovery data will be presented.

The inhibitory activity of ascorbic acid in a rich medium appears strongly species-dependent, and the contribution of acidification cannot be assumed uniform across pathogens. These preliminary findings suggest that reported MIC values are sensitive to medium composition, inoculum density and the inclusion of an appropriate acid control — factors that may contribute to the variability reported in the literature and warrant further characterisation.

Keywords: ascorbic acid, antimicrobial resistance, ESKAPE pathogens, growth kinetics, acid control

NEXT-GENERATION BACTERIOSTATIC TRANSPORT MEDIA FOR CLINICAL AND ENVIRONMENTAL MICROBIOLOGICAL SAMPLING

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Conventional transport media for microbiological swabs rely on the long-standing paradigm that sample stability requires maintaining bacteria in a nutrient-poor environment, ideally under refrigerated conditions. For long-distance transport, this requirement generates significant costs associated with the cold chain logistics, while failing to guarantee absolute sample stability.
The objective of this study was to demonstrate the potential of an innovative technology (patent application P.454716), involving nutrient-rich, bacteriostatic transport media that eliminates the need for refrigeration.
Validation studies were conducted using Klebsiella pneumoniae (carbapenem-resistant) and Staphylococcus aureus (MRSA) isolates. Pure cultures were suspended in PBS at a working titer of ~5×10^8 CFU/mL and inoculated into a modified Tryptic Soy Broth (TSB) medium supplemented with ascorbic acid and metal salts (proprietary composition). Cultures were incubated statically at 37°C for 72 hours. At 0h and 72h time points, samples were quantified via serial dilution and plated on Tryptic Soy Agar (TSA) to evaluate growth kinetics.
Validation confirmed full compliance with rigorous CLSI M40-A standards for key Gram-negative pathogens (K. pneumoniae). Composition parameters for Gram-positive strains (S. aureus) are currently in the final stages of working concentration optimization to ensure a universal spectrum of activity.
The developed technology is prepared for final certification testing. Its market implementation will facilitate the reduction of hospital costs associated with cold chain logistics and improve the accessibility of clinical diagnostics by streamlining sample transportation.

Keywords: laboratory diagnostics, cold chain logistics, ESKAPE pathogens

REMOVAL OF LEAD FROM AQUEOUS SOLUTIONS BY ADSORPTION ON SELECTED NANOMATERIALS

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Lead is a highly toxic heavy metal that can cause irreversible neurological damage, impaired cognitive development, behavioral disorders, anemia, kidney dysfunction, and cardiovascular diseases, with young children being particularly vulnerable. The persistence of lead in aquatic environments and its toxicity have made its removal from contaminated water an important environmental challenge. Common lead removal technologies include adsorption, ion exchange, reverse osmosis, chemical precipitation, membrane filtration, and coagulation followed by filtration. The choice of treatment method depends on the lead concentration, water quality requirements, treatment scale, and economic considerations. In this study, the adsorption of Pb^{2+} ions from synthetically prepared solutions was investigated using selected Slovak natural nanomaterials (zeolite from Nižný Hrabovec and bentonite from Jelšový Potok), garden waste biochar, and waste polyurethane foam. The experiments were performed at 20 °C in a closed system under constant suspension stirring. The lead concentration was determined by flame atomic absorption spectrometry. The effects of adsorbent dosage, pH, initial Pb^{2+} concentration, and contact time were evaluated. Increasing the adsorbent dosage improved the Pb^{2+} removal efficiency, whereas higher initial Pb^{2+} concentrations generally reduced the overall removal efficiency. Adsorption was strongly pH dependent and exhibited rapid sorption kinetics. The Langmuir isotherm and the pseudo-second-order kinetic model provided the best fit to the experimental data, indicating that monolayer adsorption was predominantly controlled by chemisorption. Among the tested adsorbents, bentonite resulted in the highest Pb^{2+} removal efficiency, followed by zeolite, biochar, and waste polyurethane foam. Although biochar showed moderate adsorption performance, bentonite and zeolite proved to be the most effective adsorbents. The practical application of waste polyurethane foam is further limited by its high metal content and low density.

Keywords: Adsorption of lead, Bentonite, Zeolite, Biochar, Waste polyurethane foam

DEVELOPING INTEGRATED RESEARCH INFRASTRUCTURE FOR ENVIRONMENTAL MONITORING AND CONSERVATION DECISION SUPPORT IN THE UKRAINIAN CARPATHIANS: THE EXPERIENCE OF THE INTERNATIONAL SCIENTIFIC CENTRE "OBSERVATORY"

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The Ukrainian Carpathians are among Europe's most valuable natural regions, characterised by high biodiversity, considerable landscape diversity, and pronounced vulnerability to climate change, anthropogenic pressures, and transboundary transport of pollutants. Effective investigation of these processes requires not only long-term, comprehensive observations but also modern research infrastructure capable of integrating heterogeneous environmental data, analysing them, and transforming them into scientifically grounded knowledge. In this context, the development of integrated research platforms linking monitoring, interdisciplinary research, and conservation decision support is of particular importance. To present the experience of the International Scientific Centre "Observatory" in developing integrated research infrastructure that combines long-term environmental monitoring, modern data acquisition and analytical technologies, and interdisciplinary research to investigate biodiversity, atmospheric processes, climate change, and support conservation decisions in the Ukrainian Carpathians. The infrastructure is built around a high-mountain research station on Mount Pip Ivan (2,028 m a.s.l.) and a lowland research and education unit, enabling comprehensive observations along an altitudinal gradient. It includes automated meteorological systems, ambient air-quality monitoring, aerobiological observations, biomonitoring and bioindication, biodiversity studies, phenological observations, Earth observation and remote sensing, geographic information technologies, digital systems for environmental data collection, storage, and analysis, as well as laboratory and field research facilities. The functional model integrates field observations, automated measurements, laboratory analyses, spatial assessment, and digital analytics within a single information and analytical framework, implementing the principle "from observation to knowledge, and from knowledge to conservation decisions". The International Scientific Centre "Observatory" has established an integrated research infrastructure that supports the comprehensive study of natural processes in the Carpathian region and provides a framework for the accumulation, integration, analysis, and interpretation of environmental data. The infrastructure enables long-term monitoring of atmospheric processes, aerobiological research, biodiversity and phenological observations, bioindication, remote sensing, and other areas of environmental research. Integrated analysis of the resulting data supports ecosystem condition assessment, identification of long-term environmental trends, investigation of the effects of climate change and emerging environmental contaminants, and the development of evidence-based recommendations for conservation management. The Centre also functions as an international research platform supporting open science, citizen science, environmental education, and the training of early-career researchers. The experience of the International Scientific Centre "Observatory" demonstrates the value of integrated research infrastructure as a foundation for long-term environmental monitoring, interdisciplinary research, and conservation decision support in the Ukrainian Carpathians. Combining modern scientific infrastructure, digital analytics, and international cooperation enables environmental data to be transformed into evidence-based knowledge required for biodiversity conservation, assessment of climate-change impacts, research on emerging environmental contaminants, and the development of effective conservation policy.

Keywords: research infrastructure, environmental monitoring, Ukrainian Carpathians, biodiversity, conservation decision support

DIATOMS (BACILLARIOPHYTA) AS INDICATORS OF WATER QUALITY OF THE LOWER SAN RIVER

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Reliable assessment of river ecological status requires the integration of biological and physicochemical indicators, as individual assessment methods may reflect environmental pressures in different ways. This issue is particularly important in large lowland rivers, where nutrient enrichment, changes to river shape and widespread pollution from many sources frequently occur simultaneously, potentially resulting in contrasting evaluations of ecological condition. Although the San River is one of the largest rivers in south-eastern Poland (443.4 km in length with a catchment area of 16,861 km²), the ecological status of its lower course remains poorly documented from the perspective of diatom-based biomonitoring. The aim of this study was to assess the ecological status of the lower San River by integrating physicochemical water analyses with an evaluation of benthic diatom assemblages. Surveys were conducted at three sampling sites located within the city of Stalowa Wola during four sampling seasons in 2023–2024. Ecological status was assessed using the SPI, GDI, TDI and %PT diatom indices calculated with the OMNIDIA software. The lower San River supported highly diverse diatom assemblages, reflecting the considerable habitat heterogeneity and ecological complexity of this large river system. A total of 411 diatom taxa were identified, with *Discostella pseudostelligera* and *Cocconeis euglypta* among the most abundant species. These planktonic and epiphytic taxa are typically associated with well-oxygenated, nutrient-rich waters of moderate trophic status. The dominance pattern was not restricted to eutraphentic species alone, indicating substantial habitat diversity and the relative stability of the river's microhabitats. Physicochemical analyses indicated generally good chemical status, with elevated nitrate concentrations representing the principal deviation from reference conditions. In contrast, diatom-based indices classified the river as having moderate ecological status and trophic conditions characteristic of eutrophic waters. At the same time, the low proportion of taxa tolerant to organic pollution indicated that eutrophication was not accompanied by significant organic contamination. This difference demonstrates that biological and physicochemical indicators provide complementary information on river ecosystem functioning and highlights the limitations of ecological assessments based solely on conventional water chemistry. The findings confirm that benthic diatoms are sensitive indicators of long-term environmental change, integrating the effects of multiple environmental drivers acting within river ecosystems. This study provides the first comprehensive diatom-based biological assessment of the lower San River and establishes an important baseline for future ecological monitoring. Furthermore, the results emphasize the importance of integrating biological and physicochemical indicators to achieve a more reliable assessment of the ecological status of large rivers in accordance with the objectives of the European Water Framework Directive.

Keywords: diatom indices, Bacillariophyta, San River

POTENTIAL MICROPLASTICS REMOVAL BY ROTIFERS IN AQUATIC ECOSYSTEM

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Wastewater treatment plants (WWTPs) can reduce microplastics by 80–99%, yet complete removal remains elusive. Even minimal microplastics releases accumulate overtime and harm aquatic ecosystems. This study assessed the potential of two rotifer species, *Lecane inermis* and *Philodina roseola*, to aggregate suspended microplastics. We hypothesized that microplastics aggregation is influenced by particle size, rotifer feeding strategy, and biofilm association. Fluorescent polystyrene microplastics (0.5, 1.0, 2.0 µm) were exposed to *Lecane inermis* and *Philodina roseola* under biofilm-conditioned and non-biofilm conditions. Aggregation was quantified via fluorescence microscopy using dispersed unit count (DUC) and equivalent circular diameter (ECD). Data were analyzed using negative binomial and gamma GLMMs with Type III Wald chi-square tests and Tukey-adjusted pairwise comparisons in R. The experiment showed that (i) rotifers achieved substantially higher aggregation and floc sizes with smaller particles (0.5 and 1.0 µm) compared to 2.0 µm particles; (ii) rotifer feeding strategy determined aggregation performance, *L. inermis* (biofilm-grazer) dominated in biofilm-conditioned media, while *P. roseola* (suspension-feeder) excelled in non-biofilm media; (iii) species coexistence synergistically amplified microplastics aggregation in non-biofilm conditions, with synergistic effects dependent on particle size and medium type; and (iv) biofilm-conditioned medium demonstrated higher microplastics retention with enhanced particle clustering. Overall, rotifer-mediated microplastics aggregation emerges from the interaction of environmental conditions, particle characteristics, and organism feeding traits. These findings show the ecological role of rotifers with contrasting feeding strategies in aquatic microplastics fate and suggest that targeted biological manipulation of rotifer communities could optimize microplastics removal in wastewater treatment systems.

Keywords: Biofilm, Feeding strategy, *Lecane inermis*, Microplastics, *Philodina roseola*, Wastewater treatment plants

IMPACT OF POST-HARVEST PROCESSING ON ARSENIC EXPOSURE FROM URBAN-GROWN VEGETABLES

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Urban-grown vegetables are a vital food source in many regions. However, these vegetables could be contaminated with arsenic (As) from legacy soils. Domestic post-harvest processing methods can alter both the total As concentration and its bioaccessibility in vegetables, which are key factors in dietary exposure and risk assessment. To evaluate how different post-harvest drying methods impact total As content, bioaccessibility, and the consequent human health risk from staple vegetables grown in contaminated urban soils. Carrots, beetroots, leeks, and onions cultivated in contaminated urban allotments underwent three processing methods (oven-drying, freeze-drying, or freeze-thaw-freeze drying). Total and bioaccessible As were then quantified using validated digestion and in-vitro bioaccessibility extraction protocols. Furthermore, human health risk was assessed via probabilistic models for both adults and children. Oven-drying yielded the highest apparent As concentrations and health risk estimates, particularly for children, likely due to heat-induced matrix locking. Freeze-drying and freeze-thaw-freeze drying produced substantially lower As concentrations and associated risks, more closely reflecting real-world domestic scenarios. Bioaccessibility varies by species and processing method, with freeze-thaw-freeze drying maximizing As release from plant tissues. Post-harvest processing is a critical determinant of both As content and bioaccessibility in vegetables. Therefore, adopting realistic domestic processing models is essential for accurate risk assessment and evidence-based food safety guidelines.

Keywords: Arsenic, bioaccessibility, vegetables, post-harvest, urban soils

MOLECULAR MONITORING OF MULTIDRUG - RESISTANT *KLEBSIELLA PNEUMONIAE*: CLONAL DIVERSITY AND ANTIBIOTIC RESISTANCE GENES AS EMERGING BIOLOGICAL POLLUTANTS

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Klebsiella pneumoniae is a common opportunistic pathogen found worldwide. While the classical form of this bacterium typically affects the elderly and individuals with chronic diseases, the increasing prevalence of hypervirulent (hvKP) and multidrug-resistant (MDR) strains poses a significant public health threat as these strains can also infect healthy individuals. The pathogen's ability to rapidly adapt to its environment, coupled with its evolving resistance to successive generations of antibiotics due to high clonal variability, makes treatment more difficult. As clinical facilities are the main source of resistant bacteria released into municipal wastewater, monitoring these pathogens and their antibiotic resistance genes (ARGs) is crucial, as these genes are highly persistent and pose an emerging threat to downstream ecosystems.
This study evaluated the genetic diversity of *Klebsiella* spp. strains using BOX-PCR and $(GTG)_5$-PCR fingerprinting, as well as PCR screening for multidrug resistance and virulence genes. The isolates exhibited a broad spectrum of determinants, including efflux system proteins (mdtK, acrAB-tolC), hemolysins and β-lactamases (bla_{SHV}). The carbapenem-resistance gene bla_{KPC} was present at a high frequency, reflecting the pre-selected nature of this highly resistant cohort. Genotyping revealed high overall clonal diversity, with most strains originating from multiple distinct evolutionary lineages. However, $(GTG)_5$-PCR profiling revealed a high degree of genetic relatedness among OXA-48- and NDM-positive strains in particular. Significant discrepancies between BOX-PCR and $(GTG)_5$-PCR outputs suggest that these conventional fingerprinting techniques lack the discriminatory power required for this group. Consequently, they may be inadequate for the high-resolution tracking of these emerging biological pollutants as they migrate from healthcare facilities into natural water and soil matrices.

Keywords: *Klebsiella pneumoniae*, multidrug resistance, genotyping, biological pollutants, BOX-PCR, $(GTG)_5$-PCR.

ANALYSIS OF CHANGES IN AIR QUALITY IN KRAKÓW IN THE CONTEXT OF THE INTRODUCED PRO ECOLOGICAL SOLUTIONS

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Atmospheric air pollution is currently one of the major environmental protection issues worldwide. The problem is particularly significant in large urban agglomerations. Pollutants present in the atmospheric air adversely affect human health, primarily causing respiratory and cardiovascular diseases. In recent years, a number of actions have been taken in Poland and globally to reduce atmospheric air pollution. This study presents such measures implemented in Kraków. It also examines the impact of these actions on the city's air quality. The research was based on the analysis of air quality data in Kraków spanning many years. Just over a decade ago, Kraków was characterised by very poor air quality. This condition was mainly caused by low-stack emissions and, secondarily, by road transport. Among the measures taken by the city to reduce air pollution levels are: subsidies for replacing old, non-ecological heating stoves with new low-emission ones or connecting homes to the municipal district heating network, a ban on burning solid fuels in the city, and the introduction of a clean transport zone. The first two actions resulted in a significant reduction of PM10 concentrations in the atmospheric air. The obligation to replace old, non-ecological heating stoves with new low-emission ones applies throughout Poland; however, the additional introduction of the solid fuel ban caused air quality in Kraków to improve much faster than in the rest of the region. The introduction of the clean transport zone due to nitrogen oxide air pollution, has not had such a spectacular effect so far.

Keywords: air quality, PM10, nitrogen oxides, pro ecological solutions

COMPARATIVE ASSESSMENT OF ACUTE AND CHRONIC TOXICITY OF ENVIRONMENTAL CONTAMINANTS: AN EARTHWORMS-BASED CASE STUDY

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Environmental contaminants are commonly released as complex mixtures, making their ecological effects difficult to predict using physicochemical analyses alone. Although acute toxicity tests are widely applied in environmental monitoring because they provide rapid hazard identification, it remains unclear whether mortality-based endpoints alone are sufficient for reliable environmental risk assessment. Chronic bioassays, which evaluate long-term biological responses, may reveal adverse effects that remain undetected in short-term exposure studies.
This study investigated whether acute toxicity testing alone is adequate for assessing the ecological risk of complex contaminant mixtures or whether chronic bioassays provide essential complementary information. Landfill leachate was used as a case study. Acute toxicity was experimentally evaluated using the earthworm *Eisenia andrei* according to OECD Test Guideline 207. The results were subsequently interpreted in the context of standardized chronic earthworm bioassays (OECD 222), which assess endpoints including survival, biomass change, growth, and reproduction. Acute exposure produced concentration-dependent responses, with behavioural and morphological alterations preceding mortality, demonstrating the usefulness of early stress indicators. However, comparison with chronic toxicity endpoints indicated that mortality alone may underestimate ecological risk because adverse effects on growth and reproduction can occur at lower contaminant concentrations. Consequently, chronic bioassays provide greater ecological relevance by identifying long-term effects that are not captured by acute tests.
The findings demonstrate that acute and chronic toxicity assays should be considered complementary rather than alternative tools in environmental risk assessment. Integrating both approaches provides a more comprehensive evaluation of complex contaminant mixtures and supports the development of environmentally relevant monitoring and risk assessment strategies.

Keywords: environmental contaminants, acute toxicity, chronic toxicity, earthworms, environmental risk assessment

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WATERLOGGING AS AN ENVIRONMENTAL CHALLENGE: COMPARATIVE ANALYSIS OF PHOTOSYNTHETIC RESPONSES AND RECOVERY OF DICOT (*BRASSICA NAPUS*) AND MONOCOT (*TRITICUM AESTIVUM*) PLANTS

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Climate change has been demonstrated to increase the frequency and intensity of extreme precipitation events, resulting in prolonged soil saturation and oxygen deficiency in the root zone, thereby impairing plant growth. The phenomenon of waterlogging has been shown to induce conditions of hypoxia, therefore disrupting cellular respiration, nutrient uptake, and photosynthesis. Moreover, it has been demonstrated that waterlogging promotes oxidative stress and extensive metabolic reprogramming. The aim of this study was to compare the photosynthetic performance and post-waterlogging recovery of two globally important crops with contrasting adaptive strategies: the dicot *Brassica napus* (rapeseed) and the monocot *Triticum aestivum* (wheat). We hypothesised that these differences in adaptation to waterlogging would be reflected in their physiological responses. The experiments were conducted on *Brassica napus* cv. Leo and *Triticum aestivum* cv. Harenda. The plants were germinated in pots filled with soil. At the three-leaf stage, they were waterlogged to a depth of 2 cm above the soil surface. Chlorophyll content was assessed using a Dualex Scientific+ sensor (Force-A, France). Photosynthetic performance was evaluated through chlorophyll a fluorescence measurements using a PocketPEA fluorimeter (Hansatech Instruments Ltd., UK). Gas exchange parameters, including net photosynthetic rate (A), transpiration rate (E) and stomatal conductance (gs), were determined using an infrared gas analyser (LCpro SD, ADC Bioscientific, UK). Waterlogging significantly altered the photosynthetic responses of both *Brassica napus* and *Triticum aestivum*. One of the earliest physiological responses observed was a decline in photosynthetic efficiency, with the magnitude of changes varying among cultivars. These findings suggest that the photosynthetic response to waterlogging varies between species and cultivars, and could be used to identify genotypes with improved tolerance to waterlogging stress.

Keywords: waterlogging, climate changes, *Brassica napus*, *Triticum aestivum*, photosynthetic responses

ACTIVE DECENTRALIZED RETENTION: INTEGRATED SYSTEM FOR FLOW MANAGEMENT AND STORMWATER QUALITY CONTROL

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Stormwater represents a significant natural resource, the effective management of which is a key element in developing sustainable urban infrastructure. Utilizing this potential requires an interdisciplinary approach integrating knowledge from hydrology, hydraulics, and water technology. This process involves estimating available resources and comprehensively analyzing the possibilities for reclaiming stored water. In this context, the paramount challenge lies in ensuring the continuous monitoring of collected stormwater parameters. Indeed, identification and control are absolute prerequisites for the safe implementation of innovative technologies for its reuse in urban environments. The aim of this study was to develop a multifunctional retention device to support the operation of the drainage system, enabling retention, infiltration, and the economic reuse of stormwater. The primary focus was placed on designing an integrated monitoring system for the environmental parameters of the collected rainwater and establishing an operational framework for the active control of its quality. Pilot-scale laboratory experiments were conducted using a device prototype and chromatographic analyses. Key environmental parameters requiring monitoring were identified, followed by the selection of technologically and economically optimal sensors. Measurement signals from these sensors were recorded and processed by a PLC controller. To evaluate system efficiency, simulation studies were carried out based on the analysis of flow hydrographs and water hydraulic retention times. Surface runoff studies identified key pollutant indicators, including polycyclic aromatic hydrocarbons (PAHs) and phthalic acid esters (PAEs). Additionally, six priority parameters for continuous monitoring (temperature, dissolved oxygen, electrical conductivity, turbidity, pH, and sediment level) were selected, and their threshold values determined. Simulation studies demonstrated that the most economically viable method for extending water usability for non-potable purposes (e.g., toilet flushing, irrigation) is controlled dilution with tap water. The study confirms that continuous physicochemical monitoring, combined with organic pollutant detection (PAHs, pesticides), is a key prerequisite for safe urban stormwater reuse. Integrating water quality sensors with a PLC controller enables real-time responses to composition variations, allowing quality control via economically viable dilution. The developed control algorithms successfully combine quantitative goals (supporting urban drainage) with qualitative objectives (maintaining safe water parameters), significantly advancing smart city water management systems.

Keywords: quality monitoring, PLC, stormwater reuse, retention device

LYTIC BACTERIOPHAGES AS ADAPTIVE TOOLS FOR WATER POLLUTION CONTROL: ENVIRONMENTAL ISOLATION AND EVALUATION AGAINST *ESCHERICHIA COLI* CONTAMINATION

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The increasing prevalence of multidrug-resistant *Escherichia coli* presents a significant threat to human and environmental health. It complicates infections and accelerates the spread of resistance through soil, surface water and sediments. Consequently, bacteriophages are gaining attention as a promising alternative for therapeutic and bioremediation applications. The aim of this study was to isolate, characterise and evaluate three novel lytic coliphages for controlling *E. coli* infections, including those with ESBL-type resistance, and for environmental decontamination. The phages, which were isolated from municipal wastewater, possessed double-stranded DNA genomes measuring 167,868 bp, 51,323 bp and 50,383 bp. TEM analysis classified them within the *Caudoviricetes* class (*Myoviridae* and *Siphoviridae* morphologies). The phages exhibited a rapid 10-minute latent period and large burst sizes (140 and 120 PFU/cell for two isolates). They demonstrated cross-genus lytic activity beyond *E. coli* against *Shigella sonnei* and *Klebsiella aerogenes*. At a dilution of 1%, the phages effectively degraded established biofilms in both ESBL-producing and environmental *E. coli* strains. Furthermore, they remained stable across a wide range of temperatures and pH values, as well as in simulated gastric and intestinal fluids. Under simulated water contamination conditions, free phages achieved a statistically significant mean cell count reduction of 2.31 log across seven environmental E. coli isolates and 1 log for a single subisolate at an MOI of 100. Alginate/CaCO3 encapsulated phage beads also demonstrated bacterial reduction, though to a lesser extent, with a 0.7 log reduction for the phage mixture and varying reductions for the subisolates. The promising biological properties of these phages, including lytic activity, stability, and biofilm reduction, suggest that they are viable candidates as alternatives to antibiotics and for environmental decontamination, addressing the challenge of emerging environmental contaminants.

Keywords: emerging pollutants; wastewater treatment; antibiotic resistance; bacteriophages; environmental biotechnology

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ACTIVITY-DRIVEN VARIABILITY OF BIOAEROSOL CONCENTRATIONS IN SPORTS FACILITIES

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Air microbiological quality depends on multiple factors and is particularly important in spaces intensively used for sports activities. During vigorous physical exercise, the pathway of bioaerosol particles into the respiratory tract may be shortened, increasing potential health risks for individuals. This study aimed to assess changes in airborne microbial contamination in relation to the intensity of use of a sports facility. The investigation was conducted in a gymnasium at the Sports and Recreation Center of the Silesian University of Technology in Gliwice. Air samples were collected using an impactor to determine the abundance of bacteria and fungi, while basic physicochemical parameters, including carbon dioxide concentration, relative humidity, and temperature. All parameters were measured after each group of students and before start at any activity. A significant increase in bacterial counts was observed, particularly mesophilic bacteria, reaching levels exceeding 2000 CFU/m³ after the first group of users. Additionally, psychrophilic bacteria increased markedly, while mold fungi counts showed notable fluctuations throughout the day. These changes were accompanied by rising physicochemical parameter values. Furthermore, carbon dioxide concentration and air temperature increased with room occupancy, indicating insufficient efficiency of the natural ventilation system. The findings confirm that sports facilities can promote the accumulation and spread of bioaerosols, especially under conditions of intensive use and inadequate ventilation. These results highlight the need to implement appropriate regulations and management strategies to ensure safe use of sports facilities and to minimize potential health risks.

Keywords: indoor air quality, bioaerosols, sports facilities, bacterial contamination, mold fungi,

SPIDER WEBS AS AN INDICATOR OF AIRBORNE INDOOR MICROPLASTICS POLLUTION

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Airborne Microplastics (MPs) pollution is an emerging problem with cosmopolitan distribution and potential environmental and human health implications. Cost-effective and environment friendly methods are essential to estimate the MPs in indoor environment and spider webs offer a passive and non-destructive long-term MPs monitoring. The main objective was to investigate indoor MP pollution using spider webs of two species viz; Oecobus sp. and Pholcus sp. as a non-invasive indicator. A total of 31 sites were selected in and around Lahore city with different indoor environmental conditions to collect the Pholcus sp and Ocebious sp from horizontal, vertical ceiling corners. All samples of spider webs were collected in precleaned glass vials to avoid MPs contamination and subjected to weighing, digestion, density separation, microscopy and polymer identification under controlled conditions. The data was analyzed statistically and geospatially analysis using OriginPro, Rstudio, and ArcGIS software. The highest concentration of MPs was recorded in the web of Pholcus sp (Median: 32.8; range 1.9-336 MPs/mg) followed by Ocebious sp collected from vertical corners (27.6; 1.2 - 195.5 MPs/mg), and Ocebious sp from horizontal corners (17; 0.5 – 124 MPs/mg). Fibers were the most prevalent type of MPs in all samples. The MPs abundance in webs correlate strongly with human activity patterns, high use of synthetic textile and air quality index. The study demonstrates that spider webs of Pholcus sp. could serve as an effective passive trap for airborne MPs due to their dense, irregular structure and sticky silk properties. Spider webs are low-cost, accessible for indoor MPs monitoring, human exposure risks. and contributing to environmental pollution assessment strategies.

Keywords: Indoor Pollution, Biological Indicator, Spider Web, Fibrous Microplastics, Air Quality Index

MODELLING BIOCIDE LEACHING FROM BUILDING FAÇADES INTO ADJACENT SOILS AND GROUNDWATER: A SOURCE-TO-RECEPTOR APPROACH

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Organic biocides are incorporated into renders and paints to protect building façades against algae, fungi, and other microorganisms that can cause staining and material deterioration. During rainfall, these compounds can be leached from treated surfaces, transported in runoff, and enter surrounding soils, surface waters, or shallow groundwater. However, the long-term behavior of façade-derived biocides in urban soils remains insufficiently understood. This study addresses that gap by coupling a custom Python model based on the equations of the façade-emission model COMLEAM with HYDRUS-1D to simulate the release and vertical transport of terbutryn beneath a residential area in Audenge, Arcachon Bay, France, over a 15-year period. The Python model estimates biocide emissions from façades under local weather conditions, and provides the resulting mass fluxes as boundary inputs to HYDRUS-1D. HYDRUS-1D then simulates infiltration, water flow, sorption, degradation, and solute transport through the soil profile. The simulations indicate that terbutryn may continue to be released for an extended period after the application of biocide-containing paints and renders. Because of its persistence and mobility, it can migrate progressively through the soil and may pose a risk to shallow groundwater. The coupled modelling framework provides a reusable approach for estimating soil and groundwater exposure to biocides released from building façades. The results may support the development of management measures aimed at reducing façade-derived contamination under realistic, long-term environmental conditions.

Keywords: biocides, terbutryn, façade leaching, soil transport, urban pollution

MONITORING THE RADIOACTIVITY OF VARIOUSLY USED LANDS IN THE VOLHYNIAN UPLAND

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The study area is the Volhynian Upland, a region with a long agricultural tradition dominated by arable land. Unfortunately, intensive land use can lead to elevated soil radioactivity levels resulting from the application of mineral fertilizers, particularly phosphate-based ones. Therefore, the aim of this study was to determine the activity of selected chosen radioactive elements in the arable soils of the Volhynian Upland and compare them with control sites located on forest land. Soil samples were collected from arable land under various crops, while nearby forest land served as the control. The following analyses were performed on the collected samples: particle-size distribution was determined using the Bouyoucos method (as modified by Prószyński); pH was measured potentiometrically in H_2O and 1 M KCl; organic carbon content was determined using the Tiurin method; hydrolytic acidity and the sum of basic cations were measured using the Kappen method; and the activity of radioactive isotopes (^{40}K, ^{235}U, ^{238}U, and ^{137}Cs) was analyzed using a germanium detector to measure gamma radiation emitted by the radionuclides present in the soil samples. Differences between land-use types were assessed using the Mann-Whitney U test and the t-test, depending on the normality of the distribution and the homogeneity of variance. The results confirmed that land use has a significant impact on radionuclide content in the soil environment. Among the isotopes analyzed, ^{238}U and ^{40}K exhibited significantly higher activity in agricultural soils, likely due to the application of mineral fertilizers. Higher activity levels were observed for the ^{235}U isotope, though the difference was not statistically significant. ^{137}Cs showed significantly higher activity levels in forest soils, a result of the isotope accumulating in vegetation and surface soil layers from atmospheric deposition. These findings may contribute to ongoing radioactivity monitoring, especially of radioceasium and the assessment of environmental impacts on the health of the region's inhabitants, while also suggesting that land users adjust their fertilization practices accordingly.

Keywords: soil, radioactivity, landuse, monitoring, anthropopresure

DIATOMS IN NATURALLY PETROLEUM-CONTAMINATED ENVIRONMENTS: AN INTEGRATIVE APPROACH TO SPECIES IDENTIFICATION

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Natural petroleum seeps represent extreme and poorly studied environments characterized by elevated concentrations of hydrocarbons which may be toxic to microalgae at high concentrations. Diatoms inhabiting such environments remain particularly poorly known. The aim of this study was to identify and characterize diatoms occurring in naturally petroleum-contaminated seeps in the Polish Carpathians and to evaluate the usefulness of an integrative morphological and molecular approach for their identification. Diatom populations were investigated using light microscopy and scanning electron microscopy, with additional observations of living cells by fluorescence microscopy. Species identification was supported by molecular analyses based on the ribulose-1,5-bisphosphate carboxylase/oxygenase large subunit gene (*rbcL*) and small subunit ribosomal RNA sequences (SSU). Two diatom species were identified. One species, *Halamphora lukasiewiczii* sp. nov., represents a species new to science. Its high abundance and successful proliferation in culture enabled detailed examination of both frustule morphology and living cells, providing unusually comprehensive documentation of the species. The second species, *Navicula salinarum*, is a well-known taxon and showed morphological conformity with published descriptions. However, due to its occurrence in an extreme and unusual petroleum-contaminated habitat, its identity was additionally verified using *rbcL* and SSU markers to exclude potential cryptic diversity. Our findings highlight naturally petroleum-contaminated environments as overlooked habitats for diatom diversity, including previously undescribed taxa. The results highlight the importance of integrating morphological and molecular approaches when investigating diatoms from extreme and unusual habitats and provide a basis for further studies of their adaptations to petroleum-associated environmental stress.

Keywords: algae, extreme environments, petroleum seep, integrative taxonomy, cryptic diversity

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THE EFFECT OF COMBINED EXPOSURE TO MICONAZOLE NITRATE AND ACETAMIPRID INSEKTICIDE ON BOVINE LYMPHOCYTE CULTURES *IN VITRO*

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Neonicotinoid insecticide acetamiprid is often used against sucking-type insecticide on fruit and vegetables. Its mode of action is inhibition acetylcholinesterase causing overexcitation in the nervous system and death. Miconazole nitrate in common azole antifungal drug used in veterinary medicine. It acts as an inhibitor of ergosterol synthesis and reactive oxygen species inductor. The aim of our work was to evaluate the genotoxic and cytotoxic effect of combined exposure to miconazole-nitrate and acetamiprid for 24 and 48 h in bovine lymphocytes *in vitro.* To assess these effects, micronucleus (MN) test, cytokinesis-block proliferation index (CBPI) and TUNEL assay were performed on bovine lymphocytes exposed at concentrations ranging from 0.625 to 25 $\mu g.ml^{-1}$. Whole blood used in experiments was obtained from two healthy 6-month-old bulls (Holstein crossbreed). Data were statistical analysed (Anova + Dunnett´s post test, Chí square test) After 24 h exposure, significant induction of MN from 1.25 – 12.5 $\mu g \cdot ml^{-1}$ ($p<0.05$; $p<0.01$), dose dependent reduction of CBPI from 1.25 $\mu g \cdot ml^{-1}$ ($p<0.05$; $p<0.01$; $p<0.001$), and dose dependent apoptotic cells induction at all concentrations tested ($p<0.05$; $p<0.001$. Prolonged exposure (48h) caused MN induction from 1.25-25 $\mu g \cdot ml^{-1}$ ($p<0.05$), dose dependent CBPI decrease and TUNEL positive apoptotic cell increase ($p<0.05$; $p<0.01$; $p<0.001$) in all concentrations tested. Cytotoxic and genotoxic changes detected after 48 h exposure are milder than those after 24 h treatment; probably after prolonged exposure more resistant cells stay in the cell culture and damaged ones were removed through cell processing. These complementary assays demonstrate that the tested mixture induces chromosomal damage and impairs cell proliferation, likely through mechanisms involving apoptosis and/or oxidative stress in lymphocytes.

Keywords: apoptosis, DNA damage, genotoxicity, miconazole nitrate, micronucleus

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TRACKING PESTICIDE IMPACT WITHIN A MULTI-LEVEL BIODIVERSITY MONITORING SYSTEM FOR UKRAINIAN AGRICULTURAL LANDSCAPES

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Pesticide use is a major driver of biodiversity decline in agricultural landscapes, yet its specific contribution is rarely distinguished from other pressures, such as habitat quality or climate variability, within existing biodiversity monitoring systems. Attributing observed changes in biodiversity to pesticide exposure therefore requires monitoring frameworks that explicitly isolate pesticide-related signals from these co-occurring drivers rather than treating contaminant effects as a background factor (Solé et al., 2024; Tarazona et al., 2024).

To outline how the landscape, species and molecular levels of a multi-level biodiversity monitoring system can be integrated to assess pesticide-related impacts in Ukrainian agricultural landscapes while controlling for confounding environmental drivers.

This conceptual proposal presents a nested monitoring framework. At the landscape level, pesticide application intensity is integrated with substance-specific toxicity, persistence and environmental fate (e.g., Environmental Impact Quotient, EIQ) to generate a hazard-weighted exposure index. Study sites are paired by habitat quality (semi-natural habitat cover and land-use composition) and climatic conditions, differing primarily in exposure index values. Species- and molecular-level responses – including surveys of pesticide-sensitive taxa, eDNA metabarcoding and sublethal biomarkers – are then analysed with habitat and climate included as covariates.

The framework proposes hazard-weighted exposure–effect indicator pairs for future validation, including relationships between hazard-weighted exposure and wild bee richness, and between neonicotinoid soil residues and eDNA-detected shifts in invertebrate communities. Habitat and climate variables are incorporated as covariates to isolate pesticide-specific effects. No empirical field data have yet been collected.

Integrating a hazard-weighted exposure index with paired-site sampling and covariate-controlled analyses provides a robust framework for attributing pesticide impacts within biodiversity monitoring, supporting future field validation and evidence-based biodiversity policy.

Keywords: biodiversity monitoring, pesticide impact, hazard-weighted exposure, eDNA metabarcoding, agricultural landscapes.

IRON MODIFIED CO-PYROLYZED BIOCHAR FOR MICROPLASTICS REMOVAL FROM WASTEWATER

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Microplastics (MPs) in water reservoirs has become a global environmental concern due to uncontrolled release of MPs from anthropogenic sources such as industries. The presence of MPs in water causes detrimental effects on living organisms, specifically the aquatic life being the ultimate recipient of MPs. Thus, it is very important to treat MPs containing wastewater released from industries in order to avoid this critical life-threatening issue. For this purpose, application of biochar, which is a carbon-rich sustainable material, has become equally important. Iron-rich sludge from drinking water treatment plants could also be very useful for providing nature-based solutions to resolve MPs contamination in water. Herein, iron sludge and wheat straw were co-pyrolyzed to prepare iron modified biochar for successful application to MPs containing water. The SEM results showed that iron-rich biochar possessed rough surface with numerous pores while EDS analyses revealed iron and carbon along with others as important elements in biochar. The FTIR data indicated the presence of hydroxyl and iron-rich surface functional groups which were useful in enhancing biochar performance. The XRD analyses also confirmed the presence of iron oxide in biochar structure thus proving successful formation of co-pyrolyzed biochar. The effect of environmental parameters such as pH and sorbent dose revealed that biochar was successful in treating MPs. The iron-rich co-pyrolyzed biochar considered to be a nature-friendly material due to its low-cost which could successfully remove MPs from water.

Keywords: Biochar, Co-pyrolysis, Iron; microplastics, Treatment

MICROPLASTIC MIGRATION FROM PLASTIC WATER BOTTLES UNDER EU STANDARDIZED MIGRATION TEST CONDITIONS

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Background: Plastic food contact materials are widely used but can release microplastics (MPs) into food and beverages during use, raising concerns about human exposure and potential health risks. Aim: This study aimed to evaluate the migration of MPs from plastic water bottles under Regulation (EU) No 10/2011 conditions. Methods: Fragments obtained from three commercially available plastic water bottles (4 replicas each) were filled with filtered water as a food simulant and subjected to migration testing for 2 h at 70 °C, in accordance with the heating conditions specified in EU legislation for food contact materials, along with four procedural blanks. After incubation, the simulants were vacuum-filtered (glass microfiber filters, 1.2 μm pore size), and the retained particles were stained with Nile Red and analyzed by fluorescence microscopy. MPs were quantified and classified according to their morphology and size. Blank values were subtracted from the corresponding sample counts before data analysis. Results: MPs were detected in all the samples, with median concentrations ranging from 283.4 to 483.4 MP/L (42.5 to 72.5 MP/dm²). Among the tested samples, brand C exhibited the highest MPs release (483.4 MP/L). Most detected particles (70.3%) measured 10–100 μm, while 29.7% were <10 μm. Significant differences were observed among the bottle brands in particle morphology, including circularity ($p = 0.004$) and Feret and MinFeret diameters ($p < 0.001$). Conclusions: Plastic beverage bottle fragments released microplastics into the aqueous food simulant under standardized heating conditions, suggesting that their use as food contact materials could contribute to human exposure to microplastics.

Keywords: microplastics, food contact materials, migration essays, food safety, human exposure

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INNOVATIVE SOIL AMENDMENT COMPOSITE BASED ON DIATOMITE, BIOMASS ASH, AND HYDROXYAPATITE FOR IMPROVING SOIL ENZYMATIC ACTIVITY AND SOIL QUALITY

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A multi-component soil amendment consisting of wood biomass ash, diatomaceous earth, and calcium hydroxyapatite enriched with ammonium nitrate was applied. In a pot experiment, the amendment was evaluated for its effect on soil enzymatic activity at different soil depths during the cultivation of spring barley (*Hordeum vulgare* L.). The aim of the study was to determine the optimal application rate of the soil amendment for practical use. A three-year pot experiment was conducted using application rates of 10, 20, and 40 g per pot, compared with an unfertilized control group. Soil samples were collected from depths of 0–5, 10–15, and 20–25 cm before sowing and after harvest. The activities of dehydrogenases, catalase, protease, urease, and acid and alkaline phosphatases were determined using standard biochemical methods. The data were analyzed using analysis of variance (ANOVA) and Pearson's correlation analysis. The soil amendment significantly increased enzyme activity, particularly in the 0–5 cm soil layer. The lowest application rate (10 g per pot) resulted in the strongest stimulation of dehydrogenase, urease, and catalase activities, whereas higher application rates did not increase biological activity in the deeper soil layers. Acid phosphatase activity decreased with increasing application rate, probably due to changes in soil pH associated with the ash component. Overall, low and moderate application rates were optimal for the biological activity of the tested soil amendment. The use of calcium hydroxyapatite enriched with NH_4NO_3 supplemented nitrogen deficiencies in the soil. The results indicate that the tested soil amendment is a promising and sustainable soil-improving agent that enhances soil biological functioning while enabling the beneficial reuse of biomass ash in agricultural systems.

Keywords: biomass ash, soil enzymatic activity, diatomite, hydroxyapatite, soil amendment

GREEN ROOF ECOSYSTEMS AS URBAN CARBON SINKS FOR IMPROVED AIR QUALITY

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Urbanization is reducing biologically active surfaces and increasing greenhouse gas emissions. Green roofs, as nature-based solutions, can contribute to climate change mitigation by enabling carbon sequestration in plant biomass (e.g. *Sedum* sp.) and in the substrate, improving air quality. The aim of this study was to quantify carbon storage by selected *Sedum* species on an extensive green roof by determining the total organic carbon (TOC) content in the plant biomass and substrate. The study was conducted on a 300 m² extensive green roof. Four species were analyzed: *Sedum acre*, *S. album*, *S. sexangulare*, and *S. spurium*. Biomass growth and TOC content in both the biomass and the substrate were assessed in 2025 and 2026. Results were standardized per unit area to estimate the carbon stocks of individual species and the total area of the green roof. The carbon content in dry plant biomass ranged from 434.84 to 474.90 $g \cdot C \cdot m^{-2}$, and the estimated total carbon stored in the roof vegetation was approximately 134.34 kg·C per 300 m². *Sedum spurium* had the highest TOC percentage in the biomass (41.01%). *Sedum sexangulare* stored the most carbon per unit area (383.21 $g \cdot C \cdot m^{-2}$) and showed the highest biomass growth (110.34 g). Total TOC content in the roof substrate ranged from 0.50% to 0.69%, with the highest values recorded in the substrate containing *Sedum sexangulare* and *S. spurium*. All studied species demonstrated carbon sequestration potential through the biomass growth and organic matter in the substrate, indicating two carbon storage pathways. These results suggest that extensive green roofs contribute to carbon sequestration in cities and contribute to the provision of ecosystem services by improving air quality.

Keywords**:** green roofs, carbon sinks, air quality, carbon sequestration. *Sedum* sp.

BALANCING REACTIVE NITROGEN FLUXES, TAKING INTO ACCOUNT THE DYNAMICS OF CHANGES IN ITS ENVIRONMENTAL STOCKS

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Anthropogenic emissions of reactive nitrogen (Nr) have disrupted the global biogeochemical balance. Unlike inert N_2, forms of Nr exhibit high chemical and biological activity, giving rise to the 'nitrogen cascade' phenomenon. Excess Nr leads to water eutrophication, soil acidification, loss of biodiversity and greenhouse gas emissions. Current methods for Nr balancing focus primarily on static mass balance (input-output) models, which measure annual fluxes. However, this approach does not sufficiently identify nitrogen stocks accumulated in the environment or the time lags in their release.

The aim of this article is to present a methodology for balancing nitrogen stocks and their changes over time, and to estimate so-called 'inherited nitrogen' using the Lubuskie Voivodeship as an example.

Analyses of nitrogen stock levels and the dynamics of their changes for the Lubuskie Voivodeship will be carried out based on the classical mass balance methodology, supplemented by a dynamic model of nitrogen release and retention in the environment based on statistical databases and spatial data.

Nitrogen balancing, together with an analysis of the dynamics of its changes over time, has enabled the identification of sites of long-term accumulation and delayed release of nitrogen, which are not visible in standard annual balances, and the determination of the degree of nitrogen retention in individual environmental components at the regional level.

A shift in approach to balancing nitrogen flows in the environment from a static to a dynamic one is essential for effective nitrogen management in the environment. Quantifying nitrogen fluxes and its accumulation in individual environmental pools allows for better forecasting of emissions and stocks, which facilitates the design of appropriate, long-term environmental protection strategies at regional and local levels.

Keywords: nitrogen balance; nitrogen accumulation and depletion; planning tools

WHAT DO DIATOMS LIVING IN MOUNTAIN SPRINGS TELL US ABOUT GLOBAL AND LOCAL CLIMATE CHANGE?

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Climate change, including increasing atmospheric drought and altered hydrological regimes, threatens both terrestrial and aquatic ecosystems. One of the greatest risks to biodiversity is habitat loss. Mountain regions serve as refuges for many rare and endangered species, yet their ecosystems are becoming increasingly vulnerable to climate change. Spring ecosystems are particularly sensitive because, despite their relatively stable physicochemical conditions, they may dry out as a result of disrupted water balance. This study aims to assess the impact of climate change on mountain spring ecosystems by investigating diatom communities in springs located in the Bieszczady National Park and its buffer zone.

Six springs situated at different elevations will be investigated over multiple seasons. Environmental parameters (pH, temperature, conductivity, water chemistry, and discharge) will be measured, while diatom assemblages will be analysed using an integrated taxonomic, ecological, and molecular approach. Morphological identification will be performed using light and scanning electron microscopy. In parallel, monoclonal cultures will be established for DNA extraction, followed by sequencing of the *rbc*L, *psb*C, and 18S rRNA markers. Ecological, statistical, and bioinformatic analyses will be used to evaluate relationships between diatom communities and environmental conditions.

Preliminary results indicate that springs located in proximity differ significantly in diatom species composition and serve as refuge for rare and threatened taxa. Molecular analyses have already generated the first reference sequences for several species, enriching international DNA databases.

The results highlight the importance of mountain spring ecosystems as biodiversity refuges and demonstrate their potential for long-term environmental monitoring. Multi-season analyses will determine whether the impact of climate change on mountain springs can be demonstrated by studying photoautotrophic microflora. The genetic data will be deposited in open-access databases, contributing to the development of modern tools for biological monitoring and supporting future taxonomic and phylogenetic studies.

Keywords: climate change, biomonitoring, biodiversity, diatoms, protected areas

ENVIRONMENTAL SAFETY OF MINERAL SORBENTS: CONTRASTING RESPONSES OF THE BALTIC DIATOM *SKELETONEMA MARINOI*

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Mineral sorbents are used in environmental applications, yet their effects on aquatic primary producers remain insufficiently characterized. Microalgal assays can reveal effects of released substances. This study evaluated the response of the Baltic diatom *Skeletonema marinoi* BA98 to aqueous extracts of calcium- and magnesium-based materials and examined associations with sorbent type, particle size, or processing history.

Three calcium-based sorbents differing in activation and storage history and five magnesium-based sorbents representing particle-size fractions were tested. Extracts were prepared at a 1:10 solid-to-liquid ratio. Cultures were exposed for seven days. Cell abundance was monitored on days 0, 1, 3 and 7. Day-7 responses were expressed relative to block-matched controls, and uncertainty in treatment-to-control ratios was estimated using bootstrap 95% confidence intervals. Temporal dynamics were characterized using interval-specific log-linear rates for days 0–1, 1–3 and 3–7.

Calcium- and magnesium-based extracts elicited different responses. All calcium-based extracts caused severe inhibition regardless of activation or storage history. Stored sorbents caused population collapse, whereas the freshly activated sorbent reduced abundance to 0.36% of the control. Magnesium fractions showed a non-monotonic response to particle size. After seven days, the >5 mm and >1.5 mm fractions increased cell abundance to 1137% and 648% of controls. The mixed fraction reached 117%, whereas the <1 mm and >1 mm fractions reduced abundance to 85% and 83%.

Sorbent type was more consistently associated with the response of *S. marinoi* than processing history, while particle size influenced Mg-based materials non-monotonically. Calcium-based sorbents caused severe inhibition despite differences in activation and storage, whereas magnesium-based materials ranged from moderate inhibition to strong stimulation depending on particle-size fraction. These findings indicate that sorbent composition and granulometric characteristics should be considered when evaluating materials for applications. Responses of *S. marinoi* support its use as a screening organism for sorbent safety before field application.

Keywords: *Skeletonema marinoi*, mineral sorbents, growth response, ecotoxicity, Baltic Sea

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HEAVY METAL REMOVAL FROM SLUDGE LIQUOR USING NATURAL ZEOLITE

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Sludge liquor (SL) is highly contaminated wastewater separated from sewage sludge by concentration or dehydration operations. It contains a significant load of ammonium nitrogen, organic matter, suspended solids, and also heavy metals (HMs). Commonly, SL is turning back at the beginning of the technological line, contributing to many technological problems at wastewater treatment plants. In this study, the effectiveness of using natural zeolite, i.e. clinoptilolite, for HMs removal from SL has been evaluated. The experiment was conducted in a batch mode at temperature of 20°C, mixing speed of 80 rpm and incubation time of 24 h. Various doses of clinoptilolite were investigated, i.e. 10, 20, 50, 100 and 200 g/L. An Agilent 8900 ICP-MS Triple Quad inductively coupled plasma mass spectrometer (Agilent, Santa Clara, CA, USA) was used for elemental analysis. The content of the following HMs was examined: Cr, Co, Ni, Cu, Zn, Mo, Cd, Hg, and Pb. The obtained results indicated that clinoptilolite indicated a significant effectiveness for HMs removal. The major effect was achieved for Cr, Pb, and Hg. In those cases, at the highest zeolite dose, the removal efficiency was established at level of 77.9, 63.4, and 57.1%, respectively. The lowest removal efficiency, not exceeding 12%, was obtained for Cu and Mo, respectively. Natural zeolite, i.e. clinoptilolite, might be considered as an effective adsorbent for HMs removal from SL. However, its effectiveness depends on the type of HMs and the adopted dose.

Keywords: clinoptilolite, heavy metals, sludge liquor, adsorption, wastewater treatment plant

PACKAGING MATERIAL SELECTION AS A KEY ELEMENT OF ENVIRONMENTAL MANAGEMENT

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Packaging material selection has become a strategic component of environmental management due to its significant influence on resource efficiency, energy consumption, greenhouse gas emissions, and waste generation throughout the product life cycle. The transition towards a circular economy, reinforced by the European Green Deal and the new Packaging and Packaging Waste Regulation (PPWR, Regulation (EU) 2025/40), requires packaging systems to be recyclable, reusable, and resource-efficient while minimizing environmental impacts.
This study evaluates the environmental performance of alternative food packaging materials using a Life Cycle Assessment (LCA) approach. Different packaging solutions—including corrugated cardboard, cardboard with a cellulose lid, polypropylene (PP), and rice straw packaging with a polylactic acid (PLA) lid—were compared under multiple end-of-life scenarios, including recycling, composting, landfilling, and incineration. The results demonstrate that environmental performance depends not only on the selected material but also on end-of-life management and recycling efficiency. Closed-loop recycling systems substantially reduce global warming potential, fossil resource depletion, and overall environmental impacts compared with conventional linear systems. Furthermore, increasing recycled content significantly improves environmental performance, supporting the implementation of circular economy principles.
The findings highlight that environmentally conscious packaging material selection is an essential environmental management tool, enabling companies to improve sustainability performance, comply with PPWR requirements, and contribute to climate neutrality and resource efficiency objectives within the European Union.

Keywords: Environmental management, packaging materials, Life Cycle Assessment (LCA), circular economy, PPWR, recycling, sustainable packaging

ENVIRONMENTAL IMPLICATIONS OF BIOMASS COMBUSTION ASH APPLICATION TO SOIL: EFFECTS ON HEAVY METAL AVAILABILITY AND SOIL BIOLOGICAL PROPERTIES

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The increasing use of biomass for energy production generates growing amounts of combustion ash requiring environmentally safe management. Due to its alkaline reaction and mineral composition, biomass ash may improve soil properties, but it may also affect the mobility and availability of potentially toxic elements. The aim of the study was to evaluate the effects of different types and application rates of biomass combustion ash on selected chemical and biological properties of soil, with particular emphasis on the availability of lead and cadmium. A pot experiments was conducted using two soils: Gleyic Chernozem and Haplic Luvisol. Two types of biomass ash were tested: domestic wood combustion ash and industrial ash, applied at rates of 3–15 t ha^{-1}. Soil pH, electrical conductivity, available lead and cadmium, dehydrogenase and catalase activities, and the biological fertility index were determined. The effects of ash type, application rate and their interaction were evaluated using analysis of variance and general linear models, followed by Tukey's HSD test at $\alpha = 0.05$. Biomass ash significantly modified soil chemical and biological properties, with responses depending on ash type, application rate and soil characteristics. Electrical conductivity increased with increasing ash rate, particularly after application of domestic combustion ash. Lead availability decreased with increasing ash rate in the Haplic Luvisol, whereas its response in the Gleyic Chernozem depended on ash type. A contrasting response was observed for cadmium: domestic combustion ash markedly increased its availability in the Gleyic Chernozem at higher application rates, while no significant changes were observed in the Haplic Luvisol. Biomass ash also affected enzymatic activity, with domestic combustion ash generally showing a more favorable effect than industrial ash, particularly at moderate rates. Biomass combustion ash can substantially modify soil chemical and biological properties, but its environmental effects depend on ash characteristics, application rate and soil type. The contrasting responses of lead and cadmium highlight the need for thorough assessment of ash composition and soil properties before its agricultural application.

Keywords: biomass ash, soil pollution, heavy metals, cadmium, lead

LAND USE-DRIVEN CHANGES IN SOIL NUTRIENT DYNAMICS AND ENVIRONMENTAL IMPLICATIONS

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Land-use practices can modify soil properties and nutrient cycling, thereby affecting the availability and mobility of inorganic compounds and their potential transfer within the soil–environment system. Understanding these changes is important for assessing soil quality and environmental risks associated with agricultural land management. The aim of the study was to assess the effect of different land-use systems on selected chemical and biological soil properties, with particular emphasis on the dynamics of inorganic ions and their potential environmental implications. Two complementary field studies conducted in southeastern Poland during the 2024 and 2025 growing seasons were analysed. The first compared four land-use systems, including arable soils recently converted from grassland and permanent grassland established on former arable land. The second compared a perennial willow (*Salix* spp.) plantation with a periodically mown meadow. Soil samples were collected monthly during the growing season. Soil pH, organic carbon, total nitrogen, inorganic ions and the activities of dehydrogenase and catalase were determined. Statistical analyses were performed using analysis of variance followed by Tukey's HSD test for multiple comparisons at $\alpha = 0.05$. Land use significantly affected selected chemical and biological soil properties, although the responses differed among land-use systems. In the first study, land-use differences were particularly evident in the concentrations of inorganic nitrogen and phosphate ions, organic carbon content and dehydrogenase activity. In the second study, meadow soil contained more organic carbon and total nitrogen, whereas willow cultivation was associated with higher soil pH, phosphate availability and dehydrogenase activity. In both studies, substantial seasonal variability in inorganic ion concentrations and enzymatic activity was observed. Land-use systems influence soil nutrient dynamics and biological activity and may consequently affect the mobility and environmental availability of inorganic compounds. These findings highlight the importance of considering land-use history and seasonal variability in the assessment of soil quality and potential nutrient losses from agricultural soils.

Keywords: land use, soil pollution, nutrient mobility, inorganic ions, soil quality

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CONTAMINATION OF SOILS IN THE PODKARPACIE REGION WITH POLYCYCLIC AROMATIC HYDROCARBONS

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Polycyclic aromatic hydrocarbons (PAHs) are persistent environmental contaminants formed mainly during incomplete combustion of organic matter. Due to their toxicity, persistence, and potential for bioaccumulation, PAHs pose a threat to both human health and the environment. The aim of the study was to determine concentration of PAHs in soil samples collected in the Podkarpacie region and to compare the determined values with the permissible levels specified in current Polish regulations. Soil samples were collected from recreational and agricultural areas. The QuEChERS method was used to prepare the samples, while the determination of PAHs was performed using gas chromatography coupled with mass spectrometry (GC-MS). The sum of measured PAH concentrations ranged from trace amounts to 2.660 mg/kg. In most of the analyzed samples, no exceedances of permissible limits were found, which indicates a good condition of the soil environment in the studied area. Nevertheless, the widespread presence of PAHs was observed, demonstrating their persistence and ability to migrate with airborne particulate matter and accumulation in the soil. The highest concentrations were recorded in locations heavily used by humans, such as traffic areas and urbanized areas. The qualitative composition of PAH mixtures indicates a predominance of higher molecular weight compounds, which is characteristic of pyrogenic pollution, the sources of which are primarily municipal and residential emissions and road transport.

Keywords: polycyclic aromatic hydrocarbons, GC-MS, soil, pollutant

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THE ROLE OF NATURAL SUCCESSION IN SHAPING ECOSYSTEMS IN POST-INDUSTRIAL AREAS IN KRAKOW

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Centuries of industrial activity in the Krakow area, particularly related to raw material extraction and the chemical industry, have contributed to environmental degradation and landscape changes, such as numerous excavations left after rock mining, and industrial waste disposal sites, such as the tailings ponds of the Solvay Soda Works. Some of these sites have been reclaimed for recreational purposes, constituting a valuable element of the local landscape, a place for walks and relaxation for city residents. Some of these sites, however, were abandoned after decommissioning without remediation or were only minimally reclaimed. Over the years, natural habitats have spontaneously developed on their sites through natural succession. The presentation will present examples of post-industrial sites and facilities located within the city of Krakow, such as the Zakrzówek Quarry, the Twardowski Rocks Quarry, the Liban Quarry, Bednarski Park (Krzemionki), and the Solvay Soda Works settling ponds, in the context of their history, reclamation, and environmental conditions. The role of natural succession in these sites in the formation of often highly specific natural habitats will also be discussed, with particular attention paid to rare and protected species occurring within them.

Keywords: natural succession, post-mining areas, reclamation, anthropogenic landscape transformations

PRELIMINARY ASSESSMENT OF A COMPACT RAYSID GAMMA SPECTROMETER FOR RAPID ENVIRONMENTAL RADIOLOGICAL SCREENING

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Portable gamma spectrometers offer a practical solution for rapid environmental radiation surveys by combining ambient dose rate measurements with real-time gamma-ray spectrometry and simultaneous recording of measurement locations. Their portability and ease of operation make them attractive tools for routine environmental monitoring, radiological reconnaissance, and rapid identification of areas exhibiting elevated natural or anthropogenic radiation levels.
This work presents preliminary results of an ongoing study evaluating the applicability of the compact RaySid gamma spectrometer for rapid environmental screening. Field measurements have been performed in locations representing diverse environmental conditions, including urban areas, sites characterized by typical natural background radiation, regions with enhanced natural radioactivity, and areas associated with uranium mineralization. During each survey, ambient dose equivalent rate, gamma-ray spectra, and geographical coordinates were continuously recorded, enabling spatial analysis of radiation levels and identification of local radiological anomalies. The initial results demonstrate that the instrument consistently reproduces expected background radiation levels under typical environmental conditions while clearly detecting localized increases associated with geological variability. The collected spectra also provide valuable qualitative information on the origin of elevated radiation, extending the usefulness of the instrument beyond simple dose-rate measurements. Although the RaySid spectrometer is not intended to replace high-resolution laboratory gamma spectrometry or advanced field spectrometers, its compact design, rapid response, and capability for simultaneous spectrometric and spatial data acquisition make it a valuable tool for preliminary environmental investigations and radiological screening. The presented results constitute the first stage of a broader research programme aimed at assessing the performance of compact gamma spectrometers in environmental applications. Ongoing measurement campaigns will expand the available dataset and enable comprehensive spatial analyses, comparison of different environmental settings, and further evaluation of the instrument's capabilities for routine environmental monitoring and rapid radiological assessments.

Keywords: gamma spectrometry, environmental monitoring, radiation screening, portable spectrometry, spatial analysis

COMPARATIVE STUDY OF PB(II) ADSORPTION FROM AQUEOUS SOLUTIONS USING KAOLINITE- AND SMECTITE-GROUP CLAYS

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Lead is one of the most hazardous heavy metals due to its toxicity, persistence, and tendency to accumulate in living organisms. The development of efficient and low-cost adsorbents for Pb(II) removal from aqueous solutions remains an important research focus. Natural clay minerals have attracted considerable attention because of their abundance, favourable surface properties, and adsorption potential. However, their adsorption efficiency strongly depends on their mineralogical characteristics. This study aimed to evaluate and compare the adsorption behaviour of selected kaolinite-group (halloysite) and smectite-group (bentonite) clays toward Pb(II) ions in model aqueous solutions over a wide range of initial metal concentrations. Batch adsorption experiments were conducted under laboratory conditions using model Pb(II) solutions with initial concentrations ranging from 10 to 300 mg dm^{-3}. The equilibrium adsorption capacity was calculated from the difference between the initial and equilibrium Pb(II) concentrations. Adsorption data were evaluated as a function of the initial metal concentration, and the maximum adsorption capacity (Q_{max}) was estimated using the Langmuir adsorption isotherm model to compare the adsorption performance of the investigated clay samples. The adsorption capacity increased with increasing initial Pb(II) concentration for all investigated materials. However, considerable differences were observed among the tested clay samples. Halloysite samples exhibited Langmuir maximum adsorption capacities (Q_{max}) 21.97–28.50 mg g^{-1}, whereas bentonite samples reached substantially higher values from 39.16 to 110.10 mg g^{-1}. These differences reflected variations in the mineralogical composition and physicochemical properties of the investigated materials. Both halloysite and bentonite effectively adsorbed Pb(II) from model aqueous solutions, with bentonite exhibiting markedly higher adsorption capacities. These findings highlight the influence of clay mineralogy on Pb(II) adsorption and may support the selection of suitable natural adsorbents for future water purification applications.

Keywords: lead, adsorption, halloysite, bentonite, water treatment

BIOPREPARATIONS AS A FACTOR STIMULATING PLANT GROWTH UNDER CONDITIONS OF SOIL SALINIZATION

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Plant growth and development regulators (biostimulants) are organic or synthetic compounds that play a role in regulating plant life processes. They are involved in photosynthesis and gas exchange in plants. In addition, they increase resistance to adverse environmental conditions such as drought, salinity, or pollution by toxic substances or heavy metals. Currently, one of the most widely used biostimulants is nanosilver, which improves plant health when plants are subjected to salinity stress. Foliar application of nanosilver enhances the intensity of photosynthesis and increases crop yield. Numerous studies indicate an increase in plant biomass and improved root system development. The objective of the study was to evaluate the effect of varying doses of nanosilver (Agriker Silicium) on chlorophyll content in leaves and on the development of selected parameters of chlorophyll fluorescence and gas exchange in two varieties of common oats (*Avena sativa* L.) grown under conditions of increased soil salinity. The study was conducted from 2020 to 2022 under field conditions. A strictly controlled, two-factor field experiment was designed using a randomized block design with subblocks, in three replicates. The experimental factors were the oat cultivars Poker and Bingo, and foliar fertilization with a fertilizer containing nanosilver at rates of 0.09 $L \cdot ha^{-1}$, 0.18 $L \cdot ha^{-1}$, and 0.27 $L \cdot ha^{-1}$ in the form of a preparation (Agriker Silicium), as well as a control treatment. Physiological parameters, chlorophyll content in leaves, and plant gas exchange were measured at BBCH stages 47 and 59. The results were statistically analyzed using analysis of variance (mixed model). Statistical inferences were based on Tukey's test at a significance level of $\alpha = 0.05$. The application of the SilverPlant biopreparation increased chlorophyll content in the leaves and improved the functioning of the plants' photosynthetic apparatus. An increase in the PSII function index was observed between doses of 0.18 $L \cdot ha^{-1}$ and 0.27 $L \cdot ha^{-1}$. The Parker cultivars was characterized by higher chlorophyll content in the leaves compared to the Bingo cultivar. It also achieved higher values for chlorophyll fluorescence and gas exchange indices compared to the Bingo cultivars. Foliar application of nanosilver improves physiological parameters and gas exchange in oats grown under conditions of increased soil salinity. The effectiveness of the treatment depends on weather conditions during the growing season and the biological progress of the registered cultivars.

Keywords: nanosilver, *Avena sativa* L, chlorophyll, chlorophyll fluorescence, plant gas exchange

BIOCHAR AS AN SORBENT FOR REMOVING MICROPOLLUTANTS FROM WASTEWATER

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The presence of emerging contaminants in treated municipal wastewater has become a major environmental concern due to their persistence, biological activity, and incomplete removal in conventional wastewater treatment plants. Pharmaceuticals, personal care products, endocrine-disrupting compounds, and other micropollutants are frequently detected in wastewater effluents and may negatively affect aquatic ecosystems. Biochar derived from agricultural by-products has gained increasing attention as a sustainable sorbent for advanced wastewater treatment.

The aim of this study was to evaluate the potential of agricultural waste-derived biochars as sorbents for the removal of micropollutants from treated municipal wastewater and to assess the feasibility of valorizing agricultural residues through biochar production.

A literature review was conducted using scientific databases to identify recent studies focused on the production of biochar from agricultural wastes and its application in wastewater treatment. Particular attention was given to feedstock characteristics, pyrolysis conditions, physicochemical properties of biochars, adsorption mechanisms, and the removal of organic micropollutants from aqueous systems.

Literature analysis revealed that the following agricultural wastes were used to produce biochar: straw, cereal husks, bark, bagasse, crop residues, and oil press cake. Numerous studies have shown that biochars made from this type of waste can remove contaminants such as dyes, pesticides, antibiotics, and pharmaceuticals. Previous studies indicate effective removal of the above-mentioned contaminants. Biochar achieved removal efficiency ranging from 60% to 95%. Efficiency depended on the type of biomass, pyrolysis temperature, contact time, and solution pH.

Biochars produced from agricultural wastes constitute a promising group of sustainable sorbents for the polishing of treated municipal wastewater. Their application may contribute to improved micropollutant removal while supporting waste valorization and circular economy principles. Further research is required to identify the most effective feedstocks and optimize production conditions for practical environmental applications.

Keywords: biochar, agricultural waste, micropollutants, municipal wastewater, sorption

PAHS IN SNOW COVER AS AN INDICATORS OF ATMOSPHERIC POLLUTION: A CASE STUDY OF ZAWOJA, POLAND

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Polycyclic aromatic hydrocarbons (PAHs) are persistent environmental contaminants generated mainly during incomplete combustion processes. Due to their carcinogenic, mutagenic and toxic properties, PAHs are recognized as important air pollutants and emerging environmental concerns. Snow cover efficiently accumulates atmospheric contaminants and may serve as a valuable indicator of local air quality. The aim of this study was to evaluate PAH contamination in snow cover collected in Zawoja, a mountain village located in southern Poland, identify potential emission sources, and assess the associated toxicological and ecological risks. Surface snow samples were collected at selected locations during the winter season and analyzed for the 16 EPA priority PAHs using SPE followed by gas chromatography coupled with tandem mass spectrometry (GC-MS/MS). Diagnostic molecular ratios were used for source identification. Toxic equivalent (TEQ), mutagenic equivalent (MEQ) and risk quotient (RQ) approaches were applied to evaluate potential human health and ecological risks associated with PAH contamination. The total concentration of 16 PAHs ranged from 404 to 2310 ng/L, with the highest contribution from Phenanthrene, Fluoranthene, Pyrene and Chrysene. Diagnostic ratios, including ∑COMB/∑PAH, Ant/(Ant+Ph), Flt/(Flt+Pyr), IcdP(IcdP+Bghi), BaP/BghiP, ∑LMW/∑HMW, BaA/(BaA +Chr) indicated that residential coal and biomass combustion associated with domestic heating was the dominant source of PAHs, while vehicular emissions played a secondary role. TEQ and MEQ values ranged from 58 to 179 and from 69 to 200, respectively, demonstrating the presence of PAHs with elevated toxicological significance. RQ values revealed moderate to high ecological risk for selected PAHs, highlighting the environmental significance of winter atmospheric deposition. Snow cover proved an effective medium for monitoring atmospheric PAHs deposition and assessing air quality in mountain regions during the winter season. PAHs source identification, together with TEQ, MEQ, and RQ assessments, provided a comprehensive evaluation of contamination patterns, indicating that residential heating remains the dominant source of PAHs and may contribute to adverse environmental and health effects in the studied area.

Keywords: PAHs**,** snow cover, air quality, GC-MS/MS, environmental risk

MICROBIAL DYNAMICS IN ACTIVATED SLUDGE: A COMBINED qPCR AND SEQUENCING APPROACH

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Considering the particularly harmful impact of landfill leachate on living organisms, including humans, research is being conducted on effective methods for its treatment. An important aspect of this research is the identification of key microorganisms involved in pollutant removal, as well as the analysis of the structure and dynamics of activated sludge microbial communities, which enables, among other things, the design of more efficient bioreactors. To better capture the temporal variability in bacterial community composition and gain a deeper understanding of the treatment process, a comprehensive analysis of both bacterial abundance dynamics and community structure in activated sludge was conducted in modified sequential batch reactors treating landfill leachate. Real-time quantitative PCR (qPCR) was used, complemented by high-throughput sequencing for diversity profiling. Proteobacteria dominated most samples (>50%), and their relative abundance increased significantly in the second phase of the experiment, which may indicate microbial adaptation to the environmental conditions in the reactors. Bacterial 16S rRNA gene copy numbers also varied between reactors and over time, ranging from 8.88×10^4 to 3.91×10^8 copies/mL, indicating significant dynamics. The highest bacterial counts were observed in the reactors packed with biochar (3.06×10^8 to 3.91×10^8 copies/mL). Hierarchical cluster analysis indicated that the startup phase was one of the main factors shaping microbial communities in the reactors. Principal component analysis showed that microbial variability was primarily associated with electrical conductivity, chemical oxygen demand, organic nitrogen, and total phosphorus. Combining metagenomic approaches, which enable comprehensive profiling of microbial diversity, with qPCR allowed for a more complete characterization of changes in the structure and dynamics of bacterial communities in activated sludge.

Keywords: activated sludge, landfill leachate, treatment, next generation sequencing (NGS), quantitative PCR (qPCR)

ASSESSMENT OF MICROPLASTIC CONTENT IN SOILS FROM AREAS OF INTENSIVE GREENHOUSE CULTIVATION – PRELIMINARY STUDIES

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Microplastic is one of the most serious environmental problems in the world. Growing plants in plastic greenhouses and using plastic mulch are among the main sources of microplastics in the soil. There is therefore an urgent need to understand the impact of microplastics on the physicochemical properties of soil, as well as their transfer to food chain. The aim of this study was to assess the content of microplastics in soils in areas of intensive covered cultivation. Samples were collected from cultivated fields in which horticultural production had been carried out under plastic covers for at least 5 to 20 years. To isolate plastic particles from the soil, a complex analytical procedure was performed, consisting of the following steps: sample disaggregation, size separation on wet sieves, density separation in $ZnCl_2$ solution, oxidation of organic matter in Fenton's solution, further density separation of the residue, and filtration through silica filters. A Thermo Fisher Scientific Nicolet iN10MX FTIR microscope was used to identify and determine the physical parameters of the microplastics. The average number of microplastics per 1 kg of dry matter in the soils ranged from 19 (5 years of covered cultivation) to 299 (20 years of covered cultivation). The presence of microplastics was detected in all studied soils, with polyethylene and polystyrene polymers being the dominant types. The dominant shapes of the analyzed microplastics were leaflets, and the predominant colors of the analyzed microplastics were transparent particles. The soil with the highest organic carbon content and the longest covered cultivation period had the highest microplastic count, while the soil with the lowest organic matter content but also the shortest covered cultivation period had the lowest plastic particle count.

Keywords: microplastics, plastic greenhouses, soil properties, intensive horticulture

MYCOBIOME DIVERSITY OF RUDERAL PLANTS FROM OIL-CONTAMINATED AREAS AND ITS POTENTIAL FOR BIOREMEDIATION

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Long-term oil pollution is a serious environmental problem. Petroleum hydrocarbons, including aliphatic compounds and polycyclic aromatic hydrocarbons, exhibit toxic, mutagenic, and carcinogenic effects on living organisms and significantly alter soil biological activity. Ruderal plants play a crucial role in such degraded environments due to their high adaptability and ability to colonize degraded habitats. Their rhizosphere is an area of high microbiological activity, where interactions between plant roots and fungal communities can contribute to the transformation and degradation of xenobiotics. The aim of this study was to characterize the structure and functional diversity of the rhizosphere mycobiomes associated with ruderal plants growing in areas chronically contaminated with crude oil and to assess their potential for bioremediation. Plants were collected from four oil wells representing different stages of remediation. At least ten ruderal plant species were included in the analysis. DNA was extracted from rhizosphere samples. Fungal community composition was characterized by high-throughput sequencing of the ITS region, while the functional metabolic potential of the fungal communities was assessed using Biolog FFPlates. Fungal communities were dominated by members of the phylum Ascomycota. Rhizosphere-associated mycobiomes exhibited high metabolic activity and substantial functional diversity. Both plant species and site-specific environmental conditions significantly influenced fungal community structure and metabolic profiles. The rhizospheres of ruderal plants growing in oil-contaminated areas harbor diverse and metabolically active fungal communities with potential adaptive and degradative capabilities. The observed variability suggests that plant–fungus–soil interactions may play an important role in natural bioremediation processes. However, further studies under controlled conditions are needed to confirm the bioremediation potential of these fungal communities.

Keywords: mycobiome, rhizosphere, ruderal plants, petroleum contamination, bioremediation

PHYTOINDICATIVE ASSESSMENT OF MEADOW HABITATS IN THE POR VALLEY IN THE ZAMOŚĆ REGION OVER THE LAST 30 YEARS

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The aim of the study was to conduct a phytoindicative assessment of the vegetation cover of meadow communities in the Por Valley over the last 30 years. From 2023 to 2025, geobotanical studies were conducted in the Por Valley on wet meadow communities of the *Molinietalia* order and hay meadow communities of the *Arrhenatheretalia* order of the *Molinio-Arrhenatheretea* class. Field surveys were conducted using the route method during the growing season. Phytosociological relevés taken in the field were entered into the Turboveg computer database, and then grouped into appropriate syntaxonomic units using the JUICE program. Ellenberg's phytoindicative indices (L, T, K, F, R, and N) were calculated for each relevé. The results were compared to studies conducted in this area 30 years ago. A total of 108 phytosociological relevés were taken and classified into 7 plant communities. These included *Alopecuretum pratensis*, *Cirsietum rivularis*, *Scirpetum sylvatici*, and *Holcetum lanati* from the order *Molinietalia*, and *Arrhenatheretum elatioris*, *Trisetetum flavescentis*, and *Poa pratensis-Festuca rubra* from the order *Arrhenatheretalia*. In the study area, they stood out in the mosaic of meadows and reedbeds. The highest number of species was found in the *Holcetum lanati* and *Alopecuretum pratensis* association, with an average of *Arrhenatheretum elatioris* and *Trisetetum flavescentis* per relevé. Hay meadow communities currently cover wetter habitats than in the past, while meadows in marsh habitats cover drier areas, which are now richer in nutrients than in the past. This is likely the result of organic matter mineralization, which is common in marsh habitats. Soil pH has not changed significantly over the last 30 years. An interesting phenomenon is the emergence of fresh hay meadows in wetter locations, likely a reason for the systematic mowing of meadows to meet the requirements of farmers' agri-environmental programs. In such conditions, with limited fertilization, sedges and low-value grass species are replaced by legumes and valuable forage species. Temperatures are currently higher in both fresh and wet meadow habitats, which can be explained by global climate change.

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FROM AEROMYCOLOGY TO HUMAN HEALTH IMPACT

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Fungal spores are a major component of bioaerosol and constitute an important group of biological air pollutants. As carriers of allergenic proteins, they play a key role in the development of allergic diseases. They are ubiquitous worldwide; however, their species composition and airborne concentrations vary depending on climatic zones, weather conditions, and local environmental factors. To date, over 140,000 fungal species have been described, yet only 31 are recognized as allergen sources, while up to 112 may have allergenic potential, indicating that fungal allergens remain one of the least characterized groups of environmental allergens. Allergic diseases associated with exposure to fungal spores constitute an important, yet still underestimated, epidemiological problem.

The aim of this study was to highlight the role of aerobiological monitoring of fungal spores in allergic diseases and summarize current knowledge on fungal allergens

A literature review was conducted following the principles of the PRISMA methodology.

The literature review confirms that fungal allergens exhibit considerable molecular and clinical diversity. Although IgE-mediated hypersensitivity is the predominant mechanism, fungal allergens may also induce complex immunological responses. The genera *Alternaria*, *Cladosporium*, *Aspergillus*, and *Penicillium* are of the greatest epidemiological and clinical importance. Fungal allergens are associated with allergic rhinitis, asthma exacerbations, severe asthma with fungal sensitization, and allergic bronchopulmonary aspergillosis (ABPA). Among airborne fungal spores, *Cladosporium* shows the highest prevalence and concentrations. Aerobiological monitoring enables the assessment of seasonal spore exposure, facilitates the correlation of patients' symptoms with environmental conditions, supports the interpretation of allergy test results, patient qualification for allergen immunotherapy, and the planning of preventive and therapeutic strategies.

The limited evidence regarding the allergenicity of many fungal species, together with sporadic reports of sensitization caused by these fungi, highlights the need for further research into their clinical and epidemiological significance.

Keywords: fungal allergy, fungal spores, aeroallergens, aerobiological monitoring

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DESIGN AND DEVELOPMENT OF A BIO-BASED POLYMER FILTER FOR THE REMOVAL OF MICROPLASTICS FROM WATER

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Microplastic pollution has become a major global environmental challenge due to its adverse effects on ecosystems and human health. Nature-based solutions are increasingly recognized as sustainable alternatives for water treatment. Chitosan, a biodegradable biopolymer, possesses a positively charged structure that enables electrostatic interaction with negatively charged microplastic particles, promoting their aggregation and facilitating subsequent removal from water. To design and characterize a bio-based chitosan polymer intended for the removal of microplastics from water. Modified chitosan was characterized using elemental analysis and Fourier-transform infrared (FTIR- ATR) spectroscopy. Its antimicrobial activity was evaluated by determining the minimum inhibitory concentration (MIC) according to PN-EN ISO 20776-1 against *Staphylococcus aureus* and *Escherichia coli*. Cytotoxicity according to ISO 10993-5 was performed using human epidermal keratinocyte cell line. Elemental analysis and FTIR-ATR spectroscopy confirmed the successful modification of chitosan. The modified material exhibited antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. Cytotoxicity testing demonstrated that the modified chitosan was non-cytotoxic in concentration 1 mg/ml. The developed modified chitosan showed favorable physicochemical properties, antimicrobial activity, and good biocompatibility, indicating its potential as a bio-based material for water treatment. Future studies will evaluate its efficiency in removing microplastics from aqueous environments.

Keywords: biopolymer, polymer filter, microplastics;

ENVIRONMENTAL AGING OF TIRE WEAR MICROPLASTICS: IMPLICATIONS FOR AQUATIC TOXICITY

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Tire wear particles (TWPs) are a major source of microplastic pollution and associated chemical contaminants in urban environments. However, their environmental risks under realistic aging conditions remain insufficiently understood. This study investigated the release of tire-derived chemicals and the ecotoxicity of rubber microplastics following environmental aging under ultraviolet (UV) irradiation and dark conditions in deionized water, saline water, and natural surface water. Chemical migration was analyzed using LC–MS/MS, GC–MS, and ICP, while toxicity was evaluated using *Daphnia magna*, *Lemna minor*, and *Danio rerio* (*zebrafish*) embryos. UV aging significantly enhanced contaminant release, with total organic carbon reaching 177.8 mg/L and dissolved metals up to 70,088 µg/L in deionized water. Phthalates accounted for more than 97% of the detected organic compounds under UV exposure, whereas dark aging favored polymer-derived compounds. Hexamethoxymethylmelamine (HMMM) reached its highest concentration under dark conditions (148,110 ng/L) but degraded during UV exposure. In contrast, UV irradiation, particularly in saline water, promoted the formation of 6PPD-quinone and other oxidation products. Zinc constituted more than 98% of the released metals, confirming TWPs as an important source of Zn contamination, while natural surface water modified metal mobility. Leachate toxicity strongly depended on aging conditions and water chemistry. UV-aged leachates caused 100% immobilization of *Daphnia magna*, inhibited *Lemna minor* growth by more than 50%, and reduced *zebrafish* embryo hatching success. Toxic effects were less pronounced in natural surface water, likely due to reduced contaminant bioavailability associated with dissolved organic matter. These findings demonstrate that environmental aging, salinity, and water chemistry are key factors controlling TWP-derived pollution and its ecological risks in aquatic environments.

Keywords: rubber microparticles, abiotic aging, additive leaching, aquatic ecotoxicology, 6PPD-quinone

WORKSHOPS

10 September 2026

Advanced Applications of ICP-MS in Environmental Pollution Monitoring
Workshop leader: Magdalena Podbielska (University of Rzeszów)

The workshop focuses on the practical aspects of using ICP-MS spectrometry in environmental research. Participants will learn about the latest methods for determining trace elements in water, soil, sediments, and biological materials, with particular emphasis on interference control, sample preparation, and data interpretation. The sessions will also include a discussion of real-world research cases and best analytical practices. The workshop is aimed at analysts, researchers, and practitioners interested in enhancing their skills in working with ICP-MS technology.

Hands-On Training in Environmental Toxicity Assessment
Workshop leader: Wouter Lanneau (Microbiotests), Grzegorz Piętowski, Justyna Chojnacka (Tigret)

This workshop focuses on the practical aspects of environmental toxicity assessment using modern bioassays applied in the analysis of environmental samples. Participants will learn about the principles of operation and potential applications of selected systems used in ecotoxicological research and environmental safety assessment. During the sessions, methods for assessing the toxicity of liquid samples using the BioLight, Daphtoxkit, and Algaltoxkit systems will be presented, as well as methods for testing the toxicity of solid samples, including soils, using the Phytotoxkit and Ostracodtoxkit tests. The workshop will also cover topics related to the assessment of drinking water quality using the TOXmini and Rapidtoxkit systems. The training is intended for researchers, analysts, and individuals interested in the practical application of biological methods in environmental monitoring and risk assessment.

Algae Isolation and Cultivation – Applications in Ecological and Taxonomic Research
Workshop leader: Łukasz Peszek, Mateusz Rybak (University of Rzeszów)

The workshop focuses on the practical aspects of establishing and maintaining laboratory cultures of freshwater and marine algae. Participants will learn the basic steps involved in working with biological material – from collecting environmental samples, through their transport and storage, to the isolation of specific algae species. During the sessions, methods for preparing culture media and the equipment used in subsequent stages of laboratory research will be discussed. Special attention will be given to diatoms – one of the most challenging groups of algae in terms of laboratory culture. However, the procedures and best practices presented will also be applicable when working with other groups of algae. The final part of the workshop will cover the preparation of samples for microscopic analysis and the creation of permanent slides used in biological and environmental research. The training is aimed at students, researchers, and anyone interested in practical methods for working with algae in laboratory conditions.

Turbidity Measurement – From Sample Collection to Reliable Results
Workshop leader: Grzegorz Bohosiewicz (Xylem)

Turbidity is one of the key parameters monitored in water treatment and purification processes and has a wide range of applications in environmental protection. However, obtaining accurate and repeatable measurement results depends on many factors – from proper sample collection and preparation, through correct instrument calibration, to the appropriate measurement technique. During this training, we will discuss the most important aspects affecting the quality of turbidity measurements and present best laboratory practices. The hands-on workshop session will be conducted using WTW instrumentation, allowing participants to perform calibration procedures, prepare samples, and carry out turbidity measurements themselves. We invite everyone who would like to deepen their knowledge and gain practical skills essential for obtaining reliable turbidity measurement results.

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