Lietuvos inžinerijos kolegija

Latvia University of Life Sciences and Technologies

EcoTech 2025

15th Annual International Scientific Conference on Establishment of Cooperation Between Companies and Institutions in the Baltic Sea region and the World

Book of Abstracts

19 – 21 November 2025

Grinfelde, I., Grybauskiene, V., Pilecka-Ulcugaceva, J. (Editors)

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ABOUT THE CONFERENCE

Linnaeus Eco-Tech has been an academic tradition at Linnaeus University in Kalmar, Sweden, every second year since 1997. One of the conference's key objective is to encourage research and education collaboration among Baltic Sea region countries in order to achieve long-term sustainability. Environmental challenges have become increasingly visible as they have progressed from a local to a regional to a global concern.

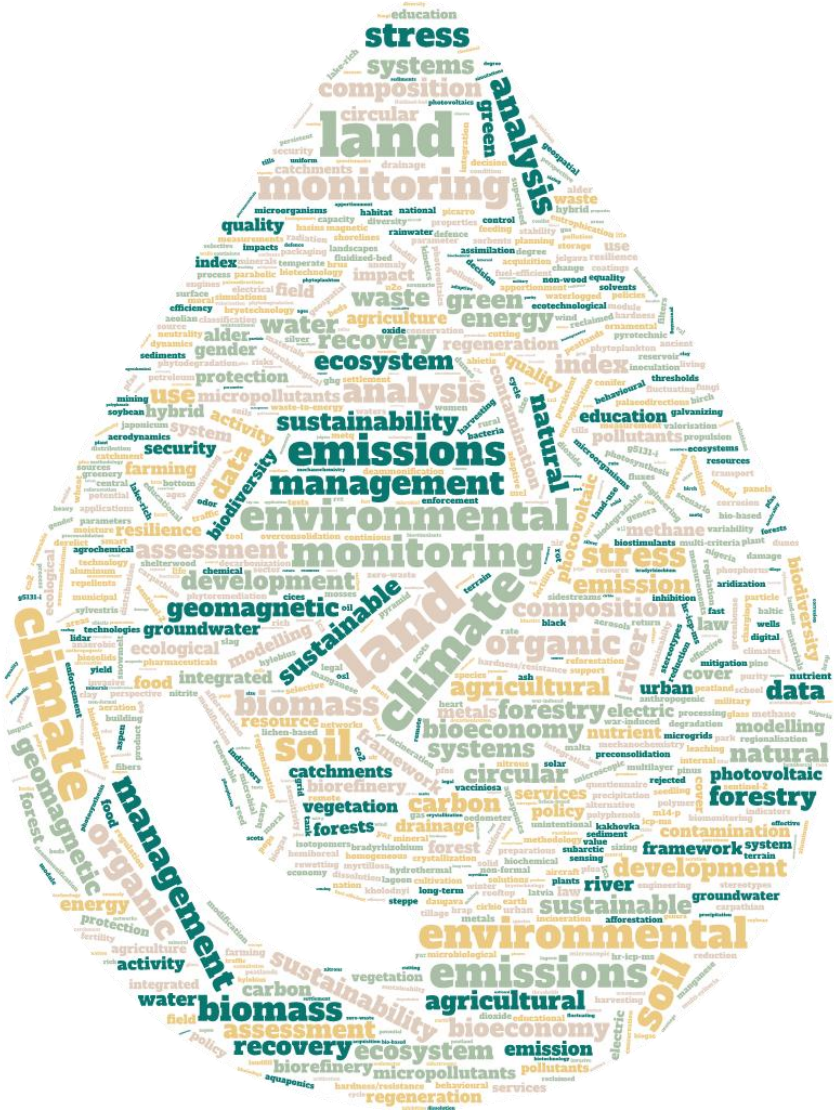
For the second time, the 15th Annual International Scientific Conference EcoTech 2025 will be held outside Sweden, taking place in Latvia University of Life Sciences and Technologies (Jelgava, Latvia) from November 19–21, 2025.

It is with great delight that we welcome you to the 15th Annual International Scientific Conference "EcoTech 2025" here at the Latvia University of Life Sciences and Technologies. We believe that the conference will offer an excellent opportunity to exchange information and to discuss state-of-the-art trends between experienced and new researchers.

TOPICS

It is proposed to invite contributions in Knowledge-Intensive Bioeconomy research fields:

1. Agriculture and Food,
2. Forestry, Biodiversity and Conservation,
3. Climate and Ecology,
4. Energy and climate neutrality,
5. Environmental engineering, sustainability, and green technology,
6. Infrastructure and Sustainability,
7. Pollution Water, groundwater and hydrology,
8. Geography, Geophysics, Geochemistry and Geology,
9. Soil Science,
10. Gender Equality and Leadership in the Armed Forces,
11. Materials and Innovation,
12. Infrastructure and Urban Development,
13. New Technologies and Digitalization,
14. Sustainable Construction and Green Technologies,
15. Security in Society,
16. Historical Perspective and Lessons Learned,
17. Project session "Innovations of Water and Nutrient Resilience"
18. Student sessions,
19. Open call for conference sessions to foster project synergy



Keyword Cloud 15th Annual International Scientific Conference on Establishment of Cooperation Between Companies and Institutions in the Baltic Sea region and the World EcoTech 2025

PROGRAMME

To make it easier for participants to navigate the event, the full conference program is available digitally. Simply scan the QR code below using your smartphone or tablet camera to access the complete program. By providing the program in digital format, the conference promotes environmental sustainability, reduces paper use, and allows for real-time updates throughout the event. Please note: An active internet connection is required to open the digital program.

Available at https://www.lbtu.lv/en/international-scientific-conference-ecotech

CONTENTS

ET002

INTEGRATION OF BRADYRHIZOBIUM INOCULANTS AND PLANT BIOSTIMULANTS FOR SUSTAINABLE ORGANIC SOYBEAN CULTIVATION

YURII SYROMIATNYKOV, ILZE VIRCAVA, ANASTASIA YAKOVLEVA, VITALIY SNITKO

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Germany, BTU-Center Europe GmbH, Ukraine, Institute of Vegetable and Melon growing NAAS

Organic soybean cultivation is an important component of sustainable agriculture and food security, yet its productivity remains strongly dependent on biological nitrogen fixation and plant physiological performance. The aim of this study was to evaluate the effectiveness of microbial inoculation with Bradyrhizobium japonicum (RIZOLINE-r) and foliar application of a plant biostimulant (KALNINI) as innovative and eco-friendly techniques for improving soybean yield and grain quality under organic farming conditions in Latvia. A controlled greenhouse experiment was conducted in 2024–2025 at the AgriHortS Institute of Latvia University of Life Sciences and Technologies using a three-factorial design: three soybean varieties (Laulema, Paradi, Tiguan), two inoculation schemes (control and RIZOLINE-r at 3 L t^{-1}), and three foliar treatments with KALNINI (no treatment, application at V3, application at R2). Measurements included plant morphometry, nodulation (number, mass, color), photosynthetic potential (SPAD index), yield, and biochemical composition of soybean grain. The results demonstrated that RIZOLINE-r inoculation increased nodule number by 48.9%, SPAD index by 16.6%, yield by 22.4%, and protein content by 1.2% compared to the untreated control. Foliar spraying with KALNINI resulted in increases of 28.9% in nodules, 10.2% in SPAD, 13.3% in yield, and 0.9% in protein content. The combined application of both preparations produced the strongest effect: nodules +64.4%, SPAD +25.8%, yield +35.7%, protein +1.9%, and fat +0.8%. Significant positive correlations were observed between SPAD and yield ($r = 0.86$), nodule mass and protein ($r = 0.74$), as well as SPAD and fat content ($r = 0.97$). These findings confirm that integrating microbial inoculants with biostimulants is a highly effective bio-adaptive strategy to stimulate symbiotic nitrogen fixation, enhance photosynthetic activity, and improve grain quality.

Keywords: **Organic farming, soybean, inoculation, Bradyrhizobium japonicum, biostimulants, photosynthesis, yield quality**

ET003

MODELLING THE IMPACT OF HEART ROT ON CARBON STOCK DYNAMICS IN FOREST STANDS AND WOOD PRODUCTS: IMPLICATIONS FOR GREENHOUSE GAS MITIGATION MEASURES

ANDIS LAZDINS, JĀNIS LIEPIŅŠ, GUNA PETAJA

Latvia, LSFRI Silava, Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava)

This study analyses the impact of heart rot on carbon stock dynamics in living tree biomass and harvested wood products under different forest management scenarios. Field sampling in spruce and pine stands, combined with laboratory analyses of wood density and carbon content, enabled the quantification of biomass losses attributable to decay. The refined methodology was integrated into the Latvian national greenhouse gas (GHG) inventory framework to assess the contribution of rot-related biomass reduction to changes in carbon storage and substitution effects in long-lived wood products. Model simulations demonstrate that decay processes significantly reduce the carbon sequestration potential of forests, particularly in unmanaged or poorly managed stands. By incorporating decay into projections of forest carbon stocks, the study provides more realistic estimates of mitigation potential. Furthermore, the analysis evaluates the effect of decay-limiting management practices, such as targeted stand treatments, on net GHG emissions and CO_2 removals on forest land. Results highlight that active management aimed at reducing the incidence of rot can mitigate carbon losses and enhance the long-term climate benefit of harvested wood products. The findings have direct implications for climate policy instruments, as they stress the importance of integrating decay dynamics into forest carbon accounting and underscore the role of adaptive management in meeting climate change mitigation targets.

Keywords: **Heart rot, Carbon, Biomass, Forests, Emissions**

ET004

IMPACT OF SOIL PREPARATION BY SPOT MOUNDING ON GREENHOUSE GAS FLUXES FROM ORGANIC SOILS IN AFFORESTED AREA (LATVIA)

ARTA BĀRDULE, ALDIS BUTLERS, NIKOLA DJUBINA, KĀRLIS DŪMIŅŠ, DAGNIJA LAZDIŅA, ANDIS LAZDINS

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava), Latvia, LSFRI Silava, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

In Latvia, the area of agricultural land (croplands and grasslands) with drained organic soils covers 170.0 kha or 6.9% of the total agricultural land area and produce GHG emissions of 3283.69 kt CO2 eq. or 96.3% of total net GHG emissions, including carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), from cropland and grassland categories reported under the land use, land use change and forestry sector in 2023. Afforestation is considered one of the potential climate change mitigation measures. Site preparation by spot mounding is a method suitable for organic soils that creates favorable growing conditions for planted seedlings, and thus increases survival and growth by enhancing root development, improving nutrient uptake, and reducing competition from vegetation. At the same time, soil structure disturbance may also have negative effects, including altering GHG flux exchanges between the soil and the atmosphere. The aim of this study was to estimate the impact of soil preparation by spot mounding on CO2, CH4 and N2O fluxes from organic soils in an afforested area (Latvia, the hemiboreal region of Europe). In total, three afforested sites (Rucava, Rembate, Smiltene) with drained organic soils were included in the study. GHG flux measurements were conducted over two years (2022–2024) using a manual dark-chamber technique for gas sampling, combined with gas chromatography to determine GHG concentrations in the samples. Measurements were conducted at three locations within each site: (i) on mounds, (ii) in mound pits, and (iii) undisturbed soil. The results show that CO2 is the largest contributor to total GHG emissions and is strongly dependent on temperature, while the contribution of CH4 and N2O emissions to total GHG emissions is minor. In general, spot mounding can alter the magnitude of GHG fluxes, either increasing or decreasing them compared to undisturbed soil depending on the type of GHG and soil conditions, including temperature and moisture.

Keywords: **Agricultural land, afforestation, carbon dioxide, methane, nitrous oxide**

ET005

SCOTS PINE PINUS SYLVESTRIS L. REFORESTATION AFTER SELECTIVE CUTTING, LATVIA

Inga Straupe, Liga Liepa

Latvia, Latvia University of Life Sciences and Technologies (LBTU)

In recent years, there has been an increasing global focus on nature conservation in forest areas, so it is important to consider under which conditions effective natural reforestation can be achieved and how sustainable use for forests can be ensured. Selective cutting provides that the structure and stability of stands are maintained, as the trees remaining in the stand after the felling of individual trees are of different heights and ages, which also provides sustainable use - stable timber growth, availability of different wood types and development of younger trees. In 2022, 8 041 thousand hectares, or 40.12% of the total area of forests that have regenerated naturally, was naturally regenerated by Scots pine. The aim of research is to evaluate whether successful pine reforestation after selective cutting is possible. The research includes young trees in Myrtillosa and Vacciniosa mel. forest types on prepared and unprepared soils. Three research objects have been developed, each research objects contains six to thirteen (depending on the site area) 25m2 sample plots (R=2.82m) established at each study site. A total of 26 sample plots were established. An inventory of naturally regenerated trees was carried out in the sample plots. The height, diameter at root collar and height increment were determined for the young trees within the plot area. The study found that two of the three study sites have sufficient trees per hectare to be considered as restored stands. In the stands where the number of trees does not meet the requirements, the soil was not prepared in advance. The average height increments of Scots pine are not the same from year to year, but the results do not vary significantly between forest types. Growth is not uniform across forest types. The difference can be explained by site-specific conditions.

Keywords: **reforestation, selective cutting, Myrtillosa, Vacciniosa mel**

ET006

SPATIOTEMPORAL ANALYSIS OF MANGANESE CONTAMINATION IN URBAN SNOWMELT: A FIVE-YEAR STUDY IN JELGAVA, LATVIA

Jovita Pilecka-Uļčugačeva, Paula Miezaka, Jana Grave, Māris Bērtiņš, Katrīna Muižniece, Inga Grīnfelde

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Liepaja University, Latvia, University of Latvia (LU), Latvia, Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technology

Manganese (Mn) contamination in urban environments is an emerging environmental and public health concern due to its persistence and potential toxic effects. This study investigates the spatial and temporal distribution of Mn in snowmelt in Jelgava, Latvia, over a five-year period (2020–2024). Snow samples were collected annually from 59 urban locations and one control site outside the city, allowing for comprehensive assessment of Mn pollution trends and sources. All samples were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), ensuring high precision in metal concentration detection. The results revealed significant spatial and interannual variation in Mn concentrations. The highest level (161.371 µg/L) was recorded in 2022 near the A8 highway, suggesting that traffic emissions are a major source of Mn in the urban environment. In contrast, the lowest concentration (0.222 µg/L) was observed in 2024 near Bemberu pond, a low-activity area with minimal anthropogenic influence. Overall, the average Mn concentration decreased from 13.01 µg/L in 2020 to 2.211 µg/L in 2024, indicating a positive downward trend in urban Mn pollution. These findings emphasize the importance of long-term environmental monitoring in assessing pollution dynamics and evaluating the effectiveness of urban environmental policies. The observed decline may reflect the impact of improved regulations, cleaner technologies, and reduced industrial activity. However, continuous efforts are needed to maintain and accelerate this trend. Future research should focus on identifying specific Mn emission sources, understanding their contribution to total pollution loads, and assessing the potential long-term ecological and health impacts.

Keywords: **Manganese contamination, heavy metals, urban snowmelt, environmental monitoring, Jelgava, ICP, MS, traffic emissions**

ET007

ANAMMOX BACTERIA RECOVERY FROM HIGH NITRITE CONCENTRATIONS BY NITRIC OXIDE FOR INHIBITION-FREE NITROGEN REMOVAL IN BIOFILM WATER TREATMENT

Ivar Zekker

Estonia, University of Tartu

Treating nitrogen-rich wastewater in conventional wastewater treatment plants via the nitrification-denitrification process is energy-intensive and costly, primarily due to high aeration demands and the requirement for external organic carbon sources. In contrast, partial nitrification combined with the anaerobic ammonium oxidation (anammox) process offers a more sustainable alternative by significantly reducing both- aeration needs and reliance on organic carbon. However, nitrite inhibition challenge in this system could be eliminated by the usage of nitric oxide (NO), a highly reactive and toxic intermediate to many bacteria other than anammox bacteria, generated by nitrogen-converting microbes, also anammox bacteria. Even at micromolar levels, NO can inhibit key microbial groups like nitrifiers and denitrifiers and contribute to atmospheric pollution. Paradoxically, NO reuse also plays a crucial stimulatory role in the anammox process. While anammox bacteria are sensitive to high nitrite concentrations, their activity can be enhanced by trace amounts of NO, helping to counteract nitrite inhibition. This study aimed to investigate how the controlled addition of specific quantities of the anammox intermediate NO effects deammonifying biofilm performance under elevated nitrite conditions (60 mg NO_2^--N L^{-1}). Quantitative PCR analysis revealed a significant increase in Planctomycetales clone P4 sequences—closely related (98–99% similarity) to Candidatus Brocadia fulgida—which abundance rose to 1×10^6 anammox gene copies per gram of total suspended solids (TSS) by day 650 of reactor operation, indicating successful enrichment and sustained activity of anammox bacteria under observed conditions.

Keywords: **biogas rejected water, deammonification, fluctuating aeration, inhibition by nitrite**

ET008

ECOSYSTEM CO2 BALANCE IN SHORT-ROTATION DECIDUOUS TREE PLANTATIONS IN AGRICULTURAL LAND IN LATVIA

Kristaps Makovskis, Arta Bārdule, Austra Zuševica, Andis Bārdulis, Andis Lazdins, Dagnija Lazdiņa

Latvia, Latvian State Forest Research Institute "Silava", Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava), Latvia, LSFRI Silava

The primary global objective for climate mitigation today is to reduce greenhouse gas (GHG) emissions and enhance their removal from the atmosphere. Targeted tree planting can facilitate the transfer of atmospheric carbon dioxide (CO2) into tree biomass and soil, thereby contributing climate change mitigation. To support implementation of this nature-based solution, region-specific quantitative CO2 sequestration and accumulation estimates at ecosystem level are necessary. The aim of this study was to estimate ecosystem CO2 balance in short-rotation deciduous tree plantations in agricultural land in Latvia including quantitative estimation of i) CO2 sequestration and accumulation in living tree biomass and ii) net CO2 emissions from mineral soil. This research synthesized previously obtained data to estimate the ecosystem CO2 balance, including both living tree biomass and soil components. Empirical data on tree growth and soil CO_2 fluxes (both efflux and influx) were collected at the study site in central Latvia (Skrīveri), which was established in spring 2011 on former cropland with mineral soil by planting seedlings of black alder, silver birch, hybrid alder, and hybrid aspen. Estimation of CO2 sequestration in living tree biomass was based on tree growth measurements obtained over an 11-year period. Estimation of soil net CO2 emissions was based on i) soil CO2 flux measurements conducted in 2020-2021 using the closed opaque manual chamber method in combination with gas chromatography and ii) estimates of carbon input into soil through tree and ground vegetation litter. The results indicate that, in addition to living tree biomass, mineral soil previously used for agriculture also has the potential to capture and store carbon. The obtained results are valuable for supporting decision makers in selecting management alternatives and providing a quantitative estimate of the ecosystem CO_2 balance in deciduous tree plantations in the hemiboreal region of Europe.

Keywords: **black alder, silver birch, hybrid alder, hybrid aspen, mineral soil, living biomass, CO2 fluxes**

ET009

RECOVERY OF ENERGY RESOURCES FROM LANDFILLS: FEASIBILITY ASSESSMENT MODEL AND ITS TESTING UNDER LITHUANIAN CONDITIONS

Gintaras Denafas, Mohsin Abdullah, Inna Pitak, Anastassia Sholokhova, Tomas Danikauskas, Algirdas Šukys, Jolita Kruopienė, Rimantas Butleris

Lithuania, Kaunas University of Technology (KTU), Lithuania, Lithuanian Energy Institute

The research addresses the EU requirement to recover valuable materials, energy resources and usable space from landfills, as foreseen by amendments to Directive 1999/31/EC. To meet these challenges, Lithuania developed an innovative model and software tool for assessing the technical, economic and environmental feasibility of landfill resource recovery. Statistical data on landfill locations, waste quantities and composition were collected and systematized, enabling the creation of a GIS-based digital map. Missing data were reconstructed using socio-economic indicators and life-cycle models. Based on these inputs, material and energy balances were prepared, forming the basis for feasibility assessments. The model was verified through pilot excavations in regional and closed landfills, where waste morphology and recovery potential were analysed. Experimental processing in mechanical–biological treatment facilities confirmed correlations between theoretical and actual results, and demonstrated the influence of treatment on waste properties. These findings allowed the verification and adjustment of the developed algorithm. Finally, the model was implemented as functional software, integrating GIS mapping with feasibility assessment modules. Tested on Lithuanian landfills, the tool generated data on recoverable material and energy potential. The main outcome is a tested decision-support solution for landfill resource recovery, applicable to regional waste management and energy systems.

Keywords: **Landfill mining, Resource recovery, Energy potential, Waste composition, Waste, to, energy, Decision support tool**

ET010

SUSTAINABILITY AND ENERGY EFFICIENCY THROUGH PHOTOVOLTAIC SYSTEMS

Esmeralda Styps, Vilda Grybauskiene

Lithuania, Kaunas University of Applied Engineering Sciences (KTK)

Climate change and the growing environmental degradation are undoubtedly among the greatest challenges facing our society today. Dependence on fossil fuels has not only driven global warming but also deteriorated air quality, severely impacting health and well-being worldwide. In light of this problem, the transition toward a renewable energy-based economy is essential for achieving a sustainable future. In this context, the integration of clean energy in urban and residential areas becomes a crucial step, as buildings account for a significant portion of global energy consumption. In order to evaluate effectiveness of photovoltaic system, methodology was created taking into consideration key parameters influencing the operation of a photovoltaic panel: solar irradiation, temperature, angle of incidence and orientation, shading and obstacles. The installation of a photovoltaic system on the facade brings numerous environmental and urban benefits, along with certain regulatory considerations. By generating energy without direct emissions, the photovoltaic system significantly reduces the building's carbon footprint. It is estimated that a 67.58 kW system could reduce around 35 tons of CO_2 annually, supporting the EU's sustainability goals. The investments into the photovoltaic system integrated on the facade will be recovered in approximately in 5 years, knowing that the first 5 years won't generate savings because of the amortization time needed. Photovoltaic systems are continually developing and improving, the only counter point it that a big amount of resource (in this case sun irradiation) needed, and not all locations are good to carry out the installation.

Keywords: **photovoltaic technology, building integration, solar panels, photovoltaic module**

ET011

THE BIOMASS VALUE PYRAMID PERSPECTIVE AND PATHWAYS FOR VALORISATION OF INVASIVE PLANT BIOMASS IN EUROPE

Evelīna Niedrīte, Linards Klavins, Oskars Purmalis

Latvia, University of Latvia (LU)

Invasive alien plants generate substantial biomass that is typically treated as waste, yet strategic valorisation can convert this liability into value based in the biomass value pyramid. The aim of this work was to review utilisation pathways for five invasive species common in Northern Europe – Lupinus polyphyllus, Reynoutria japonica, Heracleum sosnowskyi, Solidago canadensis, and Impatiens glandulifera. At the pyramid's apex, targeted extraction of bioactives (polyphenols, pigments, flavonoids, stilbenes such as resveratrol) supports pharmaceutical and nutraceutical applications. Mid-tier routes include fibre-based materials (paper, packaging), bio-based adhesives, and engineered sorbents from modified hydrochars, delivering functional properties with circular-economy benefits. At scale, biochemical and thermochemical conversions like anaerobic digestion, bioethanol, pellet/briquette production, hydrothermal carbonisation, and pyrolysis to biochar enable renewable energy carriers and soil amendments that enhance fertility, sequester carbon, and mitigate allelopathy. Sinergistic evidence indicates potential for greenhouse-gas reduction and ecosystem-service gains when valorisation is coupled with control operations. Key constraints are biomass heterogeneity and seasonality, limited process standardisation at scale, logistics and policy barriers, and the need for strict protocols to eliminate propagules during processing. Aligning species traits with processing choices and prioritising high-value fractions before energy recovery can maximise ecological and economic returns. Integrated, region-specific biorefinery concepts based on lab and pilot scale trials can create further impact across Europe in biomass valorisation strategies.

Keywords: **Invasive plant biomass, valorisation, biorefinery, biomass value pyramid**

ET012

GENDER EQUALITY PRACTICES IN THE LATVIAN ARMED FORCES

Iļija Jēgers, Jovita Pilecka-Uļčugačeva, Dita Blumberga

Latvia, Latvian National Defense Academy, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Gender equality is increasingly treated as a strategic resource for modern armed forces, shaping both security outcomes and the effectiveness of operational tasks. In Latvia, the principle of equality is rooted in the Constitution and national legislation, including the Labour Law and the Military Service Law, and further reinforced through international obligations such as the CEDAW Convention and UN Security Council Resolution 1325. Despite these formal commitments, daily practice within the Latvian Armed Forces still reflects persistent challenges. The present study set out to evaluate how gender equality is addressed in theory and applied in practice, with a particular focus on the Training and Doctrine Command. A qualitative methodology was used, drawing on structured interviews with eight officers and NCOs from the National Defence Academy and the Mechanized Infantry Brigade. The results indicate that progress is visible, especially through the gradual rise of women in leadership roles. At the same time, entrenched stereotypes regarding physical strength and combat suitability remain influential, dropout levels during training are comparatively high, and women continue to be underrepresented in senior command posts. To ensure lasting improvement, the study recommends stronger institutional leadership, clearer and more transparent anti-discrimination procedures, and targeted recruitment measures inspired by NATO allies' experience. Advancing equality strengthens defense.

Keywords: **gender perspective, gender stereotypes, women in defence, equality policies**

ET013

METHODOLOGICAL APPROACH TO ASSESSING BIODIVERSITY IN DIFFERENT TYPES OF LAND USE IN LATVIA

Sniedze Više, Aleksejs Nipers, Kristīne Bīlande

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Faculty of Economics and Social Development, Latvia University of Life Sciences and Technologies

Over the last 30 years, economic development has led to a previously unseen decline in biodiversity both globally and in Latvia. The 2023 Latvian Nature Census Report highlights the rapid loss of grasslands, biologically valuable forests, natural marshes, and freshwater habitats, with biologically valuable grasslands occupying only 0.9% of the territory. This situation, combined with the EU Biodiversity Strategy 2030 objective - each Member State protects 30% of its territory for habitats and species, highlights the need for new knowledge on biodiversity assessment across land uses. It further underlines the importance of scientific solutions that can guide sustainable planning and land use management. Nowadays, standardized tools, especially different quantitative indexes and models, are increasingly used for biodiversity assessment and also for supporting policy decisions. Among them, indicators like MSA (Mean Species Abundance) and BII (Biodiversity Intactness Index) play an important role and are included in larger models such as GLOBIO. These tools make it possible to evaluate the reduction of species abundance in different land use types by comparison with the undisturbed environment before human intervention, taking into account the main influencing factors e.g. land use change, fragmentation, infrastructure development. Although these indexes provide valuable insights on a global scale, they often fail to accurately reflect local conditions due to limitations such as low spatial resolution and lack of data availability at the national level. Considering these challenges,it is necessary to adapt the tools to regional specific conditions and available data in order to obtain information that is practically useful for sustainable land management and policy planning. The study offers a methodological approach for biodiversity assessment in Latvia across different land use types, integrating the most important influencing factors and sustainability principles.

Keywords: **biodiversity indicators, biodiversity index, species protection, land use**

ET016

MOSSES *(BRYOPHYTA)* AS A RESOURCE FOR BIOECONOMY AND MOST PROSPECTIVE DIRECTIONS OF THEIR USE

Laura Klavina

Latvia, University of Latvia (LU)

Mosses are one of the largest plant groups that are abundant in all ecosystems and has potential to serve as a source for biomass in bioeconomy. As mosses belong to simplest organisms, their phytochemistry differs from that of highest plants. Nevertheless research shows that their chemical composition is unique, if to be compared with higher plants, and with potentially useful compounds for use in pharmacognosy. The aim of this study is to analyze potential moss usage as a resource for bioeconomy and their biorefinery possibilities accordingly to biomass value pyramid. Analysis of current literature dedicated to moss composition, phytochemistry, reveal significant application potential in bioeconomy. Experimental analysis using extracts of bioactive components and analysis of structure of mosses abundant in Northern Europe shows principally different composition and structure of bioactive components in comparison with vascular plants. Considering concepts of biomass value pyramid, biomass processing accordingly to green chemistry principles as most promising can be considered moss extraction with low polarity solvents for production of added value substances for application as pharmaceuticals, in cosmetics, as well as food preservatives, considering their unique biological activity that includes antimicrobial activity. As a tool for production of moss biomass for further processing the cultivation of their cells using biotechnological approaches (bryotechnology) can be suggested.

Keywords: **mosses, bryotechnology, chemical composition, bioeconomy**

ET017

BIO-BASED REPELLENTS AS ALTERNATIVES TO INSECTICIDES FOR PROTECTING CONIFER SEEDLINGS FROM THE LARGE PINE WEEVIL

Ilze Matisone, Kristaps Ozoliņš, Roberts Matisons, Mārtiņš Spāde, Uldis Grīnfelds, Rinalds Trukšs, Liene Zēberga

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava), Latvia, SIA "Global Consulting"

Environmental concerns regarding the intensive use of insecticides necessitate the research for sustainable alternatives such as biological repellents against Europe's most damaging pests of conifer seedlings – the large pine weevil Hylobius abietis. In 2025, across the Baltics, the effectiveness of experimental biological repellents, consisting of plant-based oils (e.g., canola, linen), softwood bark extractives, solvent, needle wax, and a weak alkaline, in comparison to two commercially available repellents, Conniflex and Woodcoat, was tested. In Estonia and Lithuania, a stand of Norway spruce Picea abies and Scots pine Pinus sylvestris was established with treated and untreated containerized second-year saplings. In Latvia, one Norway spruce and two Scots pine stands were established similarly. In spruce stands, four treatments were compared: untreated (control), Woodcoat, and two modifications (by proportions) of the experimental repellents. In the pine stands, the efficiency of Conniflex and the two modifications of the experimental repellent were tested against the control. Feeding damage by H. abietis was visually assessed on 100 seedlings per treatment using a six-point severity grade. Each tree was inspected along the entire stem length, with particular attention given to the root collar. Complementary laboratory tests were performed to support field results, though the main focus remains on plantation-level outcomes. This study aims to provide robust comparative data on the potential of bio-based repellents as ecologically safer alternatives to current commercial products for protecting young conifer plantations.

Keywords: **Hylobius abietis, seedling protection, feeding damage, Scots pine, alternative repellents**

ET018

TREE-RELATED MICROHABITAT DIVERSITY AND ABUNDANCE UNDER UNIFORM SHELTERWOOD IN SCOTS PINE-DOMINATED STANDS IN HEMIBOREAL FOREST ZONE

Māra Kitenberga, Jānis Donis, Pāvels Rigalovs, Leonīds Zdors, Roberts Matisons

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava)

Forest management systems like uniform shelterwood (SW) has less destructive impact on vascular plant and bryophyte communities. SW is a form of continuous cover forestry (CCF) management systems that, by omitting abrupt changes in canopy covers aims to reduce negative effects of felling on biodiversity and other ecosystem services. Tree related microhabitats (TreMs) are important biodiversity carrier for several specialised species. However, the abundance and diversity of TreM have been scarcely studied in stands where SW has been implemented. The objective of this study was to describe abundance and diversity of TreMs in Scots pine-dominated stands where one or two partial shelterwood cuttings have been performed. The survey was conducted 189 Scots pine-dominated stands. Within each stand, four 500m2 circular sample plots were established, in which stand characteristics were measured and the occurrence TreMs recorded. The effects of stand characteristics and management practices (one or two partial cuttings) on TreM abundance and diversity were estimated using generalized linear mixed-effect model. The abundance of TreMs was significantly affected by tree species, tree status (living canopy tree or standing deadwood), diameter, number of partial cuttings, stand age, as well as the interaction between tree species and number of partial cuttings indicating complex influences. In the stands, where two partial cuttings have been implemented, the number of TreMs was significantly lower in comparison to the stands that had undergone a single partial cutting. For the deciduous tree species, the number of TreMs was significantly higher than for coniferous tree species.

Keywords: **uniform shelterwood, Pinus sylvestris, regeneration, continious cover forestry**

ET019

EFFECT OF STAND CHARACTERISTICS ON REGENERATION PATTERNS OF SCOTS PINE UNDER UNIFORM SHELTERWOOD

Māra Kitenberga, Jānis Donis, Leonīds Zdors, Pāvels Rigalovs, Elferts Didzis, Roberts Matisons

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava)

Continuous–cover forestry (CCF) has been widely debated alternative to traditional rotation-based retention forestry, particularly due to potential to maintain biodiversity and to provide social benefits. However, the empirical evidence on regeneration success under CCF under hemiboreal conditions is scarce. The aim of the study was to estimate the regeneration success of Scots pine in hemiboreal single-species dominated stands following selective cutting in a mid-term perspective. In total, 189 stands were surveyed where the first partial cutting was carried out 10–17 years ago. In each stand, four circular 500 m2 sample plots were established, where all canopy trees were measured. Additionally, within each plot, three subplots (12.5 m2) were established, where regeneration (all trees smaller than 4 m of those with stem diameter at breast height <2.1 cm). Linear mixed effects model was used to relate characteristics of regeneration with the variables describing the stand (canopy trees). Scots pine regeneration density was affected by forest site type, stand density, tending and regeneration density and height of co-occurring tree species. Furthermore, interactions between tending and forest site type, as well as the interaction between soil preparation and forest site type showed complex effects of management and site conditions. The further research is required to compare regeneration and subsequent growth dynamics of regenerating trees under uniform shelterwood with those established under gap or strip cutting systems across different soil conditions.

Keywords: **Scots pine, natural regeneration, uniform shelterwood, hemiboreal forests**

ET020

SPRINGS AS INDICATORS OF GROUNDWATER QUALITY AND POLLUTION RISKS

Inga Retike, Jānis Bikše, Oskars Purmalis

Latvia, University of Latvia (LU)

Groundwater remains poorly monitored and is often referred to as an "invisible resource." Springs, as natural groundwater outflows, serve as drinking water sources, sustain groundwater-dependent ecosystems, and reflect both natural processes and human pressures within their catchments. In Latvia, elevated nitrate concentrations have been recorded in shallow wells and springs, at times exceeding the EU threshold of 50 mg/L. Pesticide contamination has also been observed, though comprehensive national-scale data are lacking. To address this gap, we carried out a survey of Latvian springs to understand the processes governing their composition and to identify potential anthropogenic impacts. As an initial step, we used citizen-generated data to identify spring locations in Latvia through a web-based mapping platform (avoti.info) launched in 2021. From these, 57 springs were selected and analyzed for major ions, nutrients, trace elements, and pesticides. Multivariate statistical methods, including Principal Component Analysis, were applied to the dataset. Our results confirm that springs provide critical insight into groundwater quality and pollution risks. The study identified four dominant hydrochemical processes: upland recharge from unconfined aquifers, reducing conditions in confined aquifers, gypsum dissolution, and agricultural impacts on water quality. Current management measures, such as nitrate vulnerable zone designations, appear misaligned with the observed data. Several pesticides were also detected, including 2,4,6-trichlorophenol, hexachloro-1,3-butadiene, propazine, simazine, metazachlor, clothianidin, imidacloprid, thiamethoxam, and propiconazole. Although most of these compounds are banned in the EU, they still persist in groundwater. The research is supported by GRANDE-U project “Groundwater Resilience Assessment through iNtegrated Data Exploration for Ukraine” (Latvian Council of Science No. 11-1.N-462).

Keywords: **groundwater quality, pollution, catchments**

ET021

CONTENT AND TASKS OF GEOSPATIAL DATA OF ELECTRICAL NETWORKS AT THE TURN OF THE CENTURY IN LATVIA.

Maris Virkavs, Vivita Pukite, Armands Celms, Toms Līdumnieks

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Institute of Land Management and Geodesy, Latvia, ZIGI

Significant research has been conducted in Latvia on the technical development of electrical networks, but there is less information on changes in network infrastructure geospatial data and cartographic materials over time. This is important today, when the digital transformation of critical infrastructure data is taking place, the use of remote sensing methods is increasing significantly, but at the same time, historical experience must not be lost. The study has compiled archival materials and information available from individual network companies about cartographic materials used, starting from the beginning of the 20th century to the present day, when the triumphant march of geographic information systems has taken place. It is concluded that the development of geospatial information can be divided into three (multiple) stages. The first was the initial stage at the beginning of the 20th century, when electrical networks developed in local areas, mainly as a source of lighting. The second stage after 1939, when the Ķegums hydroelectric power station, the largest in Latvia at that time, was put into operation. Thus, electricity transmission could begin throughout the country via 80kV network lines. The third stage of the country's industrialization and electrification of rural areas during the period from the loss of independence in 1940 to its restoration in 1991, as well as the final stage in the last 30 years. It has been concluded that as the technical performance of network construction and the state's public infrastructure have changed, the data content, data usage options, and data availability have changed.

Keywords: **Electrical networks, geospatial data**

ET022

CHARACTERIZATION AND ENVIRONMENTAL IMPLICATION OF NON-HAZARDOUS WASTE INCINERATION BY-PRODUCTS: UNDERSTANDING OF THE PARTICLE SIZE DISTRIBUTION, MINERALOGICAL COMPOSITION, ELEMENTAL ANALYSIS AND LEACHING BEHAVIOR

Bilal Touseef, Gytis Matiženok, Gintaras Denafas

Lithuania, Kaunas University of Technology (KTU)

This study analyses the composition and environmental impact of non-hazardous waste incineration by-products. The main objective was to assess the mineralogical and elemental composition of these by-products, determine their leaching behavior and expolre their possible safe applications. The study will attempt to solve the problems posed by these residues to the environment. The bottom ash and slag were taken from the Kaunas Cogeneration Power Plant and mechanically sieved to obtain four different granulometric fractions (0-2 mm, 2-5 mm, 5-12 mm and 12-50 mm). X-ray diffraction (XRD) and scanning electron microscopy (SEM) were employed for determining their mineralogical and elemental composition. The heavy metals such as Cd, Pb, Cr, Cu and Zn were quantified using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The distilled water and a mixture of hydrochloric and nitric acid were used as the leaching tests so as to stimulate the environmental exposure at a proportion of 10 L/kg of liquid to solid. The results showed that the 0-2 mm fraction was 45-50 percent of the total sample; therefore, controlling the particle size distribution of the materials. In the analysis of ICP-OES, the metal levels were found to be 5 to 600 mg/kg, and they were all not above the environmental hazardous waste regulation limits. The results of leaching tests showed that the level of metals in the eluates was also not exceeded, cadmium (Cd) at less than 5 µg/L, lead (Pb) at less than 50 µg/L, chromium (Cr) at less than 25 µg/L, and zinc (Zn) at less than 100 µg/L. It is concluded that the bottom ash and slag of the Kaunas Cogeneration Power Plant are safe to be used in the second time and not a significant threat to the environment, which is a viable alternative to reuse these by-products in other industrial sectors, such as construction.

Keywords: **bottom ash, slag, particle size distribution, metals leaching**

ET023

FROM EVIDENCE TO SCENARIOS: DEFINING A MULTI-CRITERIA FRAMEWORK FOR SUSTAINABLY MANAGING DRAINED ORGANIC SOILS IN AGRICULTURAL RIVER-BASIN LANDSCAPES

Annija Danenberga, Kristīne Bīlande

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Meža un ūdens resursu zinātniskā laboratorija

Drained organic soils within agricultural landscapes illustrate a major environmental challenge, generating disproportionately large sources of greenhouse gas emissions and nutrient runoff relative to their limited share of production. Due to extensive drainage, their impacts may extend beyond field boundaries, altering hydrological cycles, degrading water quality and reducing ecosystem services at the river-basin scale. This study synthesizes existing academic evidence on the management of drained organic soils in agriculture to develop a multi-criteria framework for sustainable land use, with particular attention to transboundary river basins. A systematic literature analysis identifies leading management practices, their environmental, agronomic, and socio-economic impacts as most frequently applied assessment indicators. The review reveals that while drainage-based agriculture remains dominant, alternative strategies – implemented as diverse, mosaic-type territorial land use configurations, such as controlled drainage, rewetting and paludiculture - demonstrate potential to balance production with reduced emissions and enhanced ecosystem services. However, studies highlight a lack of integrated approaches that consider multiple criteria simultaneously. Building on these insights, the proposed framework shall integrate environmental (GHG emissions, nutrient runoff, soil degradation, biodiversity), agronomic/technical (productivity, management feasibility, resilience), and socio-economic/governance (farm income, policy alignment, stakeholder acceptance) dimensions. In doing so, this framework may serve as an evidence-based foundation for developing and evaluating alternative land-use scenarios for organic soils, acting both as a tool for identifying knowledge gaps and guiding case study applications. Thereby, the study contributes to advancing integrated land management strategies for drained organic soils in agricultural riverine peat landscapes.

Keywords: **Organic Soils, Peatlands, Agricultural Landscapes, River Basins, Multi, Criteria Analysis Framework, Integrated Land Management**

ET024

RECLAIMED WATER FOR USE IN AGRICULTURE AND NUTRIENT RECOVERY IN NORTHERN EUROPE: CASE STUDY IN LATVIA

Oskars Purmalis, Jānis Zviedris, Evelīna Niedrīte, Iveta Pugajeva

Latvia, University of Latvia (LU), Latvia, Institute of Electronics and Computer Sciences, Latvia, Institute of food safety, animal health and environment "BIOR"

Reclaimed water use is of growing significance considering growing water consumption and thus water scarcity, as well as the impacts of climate change. The main area of reclaimed water use is in agriculture, but also in recreation, urban landscaping and for other purposes. Nutrients, present in reclaimed water, can support crop growth and yield at the same time reducing surface water pollution, and this aspect is especially important to reduce nutrient loading to the seas. Despite topicality, the use of reclaimed water in Northern Europe is still very limited, thus urging demonstration of feasibility and rising public acceptance. As main aspects limiting usage of reclaimed water is potential risks and presence of contaminants also in treated water. Therefore demonstration cases and successful applications will provide necessary awareness not only to society, but will enhance discussions and preparation of legal framework in individual countries. A case study in Latvia (Ugāle wastewater treatment facility) demonstrates the efficiency and feasibility of reclaimed water use in agriculture. Presence of major groups of pollutants (nutrients, heavy metals, pharmaceuticals and others) of concern in reclaimed water has been analysed. Transfer of metals and nutrients from reclaimed water to plants has been studied, and no major risks have been found. Reclaimed water quality corresponds to low risk with respect to applications, but demonstrations of use for the cultivation of plants support wider regional applications.

Keywords: **Reclaimed water, nutrient assimilation, pharmaceuticals in waters, heavy metals, agricultural applications**

ET025

AQUAPONICS IN THE CENTRAL BALTIC REGION: PERSPECTIVES, CHALLENGES, AND OPPORTUNITIES FOR SUSTAINABLE FOOD PRODUCTION

Oskars Purmalis, Paula Luīze Biteniece, Lauris Arbidans, Linards Klavins

Latvia, University of Latvia (LU), Latvia, Riga Technical University (RTU)

Aquaponics as soil-less farming system accompanies aquaculture and plant production which offers a resource-efficient approach to food production by simultaneously producing fish and vegetables while minimizing water use and nutrient losses. In the Central Baltic region, interest in aquaponics is growing due to its potential to contribute to circular bioeconomy strategies, reduce nutrient runoff, and support local food security. However, registered commercial aquaponics are in small number indicating limitations to their wider participation in the market. Therefore analysis of the current state, challenges, and future prospects of aquaponics technology in Central Baltic area is with high importance. Such results will be beneficial for policymakers, entrepreneurs, and researchers about pathways for developing resilient, low-impact food systems. Thus, aim of the study is identification, analysis of limitations, bottle-necks for successful development of aquaponics systems in Central Baltic area. Among identified limitations and barriers are high energy costs, regulatory gaps for fish and plant production integration, limited technical know-how, and seasonality impacts under Nordic climate conditions. Despite presence of unique ideas and applications still knowledge and solutions for valorisation of side streams is limited, affecting potential integration with renewable energy systems, and potential for production of high-value crops. The study highlights the need for collaborative research, pilot systems, and transnational knowledge exchange to unlock aquaponics' potential within EU Green Deal and Bioeconomy Strategy frameworks.

Keywords: **aquaponics, circular bioeconomy, sustainable food systems, Central Baltic**

ET026

FEASIBILITY OF ENERGY GENERATION BY INCINERATION FROM MUNICIPAL SOLID WASTE IN TERMS OF TECHNO-ECONOMIC ANALYSIS IN CITIES OF PAKISTAN

Mohsin Abdullah, Gintaras Denafas, Hanna Bibi

Lithuania, Lithuanian Energy Institute, Lithuania, Kaunas University of Technology (KTU)

The incineration process is a widely used method in which waste is burned to generate electricity and heat. Energy generated from waste addresses two major challenges, i.e. effective waste management and supply of electricity for both domestic and industrial applications. for this reason, the incineration process must be feasible in term of economic and technical prospective. In this study, the feasibility of an incineration plant was evaluated in the Hazara Division of Khyber Pakhtunkhwa (KPK), Pakistan, specifically in the district of Haripur and Abbottabad. the energy potential from total waste generated was calculated by different population sizes, using the lower calorific values of various waste types in Municipal solid waste. the district of Haripur and Abbottabad, with a combined population of 2.5 million, generate about 1141.29 t/day of waste, which has an energy potential of 140.18 GWh/y. Similarly, the Hazara Division, with a population of 6.1 million, generates around 2723.04 tons/day of municipal solid waste (MSW), with an energy potential of 334.464 GWh/year. Economic indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Levelized Cost of Energy (LCOE) were analysed. The results indicate that: NPV remained negative for all population sizes. IRR was found as 8% for the districts of Abbottabad and Haripur and 15% for Hazara division, keeping the discount rate constant at 10%. LCOE decreased as the population size increased. A strong correlation of 0.9876 was observed between LCOE and population size. The findings of this study suggest that considering an incineration plant exclusively for the districts of Abbottabad and Haripur will not be feasible. However, if the entire Hazara Division is taken into account, the installation of incineration plant will be feasible with an IRR of 15%, which exceed the 10% discount rate. This study will provide valuable insights for policy makers, industrialists and researchers.

Keywords: **Municipal Solid Waste, Incineration, Internal Rate of Return**

ET027

IMPACTS OF DRAINAGE DITCH DEEPENING ON FEN HYDROGEOLOGY AND RESTORATION SCENARIOS USING MODFLOW

Gustavs Jorens Baumanovskis, Jānis Bikše, Inga Retike, Normunds Stivriņš

Latvia, University of Latvia (LU)

Wetland protection depends strongly on groundwater discharge and dynamics, yet many fens or their margins have been drained for agricultural purposes. The Natura 2000 site Platenes fen, located in the Latvian coastal lowland, borders a former agricultural area with extensive ditch and tile drainage systems active for over 50 years. Recently, land conversion to a solar energy facility required further ditch deepening, causing groundwater level decline. Since solar panel operation does not require low water levels, the potential for rewetting the drained area warrants investigation. In this study, a MODFLOW groundwater flow model was developed to simulate conditions before and after ditch deepening, and to explore future rewetting scenarios. The model was constructed using data from five groundwater monitoring wells, supplemented by meteorological and soil survey information. Calibration was performed through a trial-and-error approach and refined using the PEST optimization tool. The results indicate that ditch deepening primarily affected the fen periphery, lowering groundwater levels, while the central fen remained less impacted. Scenario simulations of ditch blocking demonstrate the potential to restore a more favourable hydrological regime in the fen. Moreover, raising the water table beneath the solar panel field enhances peat soil water retention, contributing to CO_2 sequestration. These findings suggest that, with appropriate management, the hydrological regime of the fen can be improved to a state surpassing pre-construction conditions. This highlights the possibility that adjacent land-use changes, if properly mitigated, may contribute to the restoration of natural wetland ecosystems. The research is supported by GRANDE-U project “Groundwater Resilience Assessment through iNtegrated Data Exploration for Ukraine” (Latvian Council of Science No. 11-1.N-462).

Keywords: **Rewetting, Photovoltaics, Simulations, Groundwater, Peatland**

ET028

FEEDING SIMULATION MODEL: DATA ACQUISITION TO ACHIEVE CLIMATE NEUTRALITY GOALS

Sarma Cakula, Vineta Silkāne, Mairita Zaķe, Oskars Java

Latvia, RISEBA University of Applied Sciences

According to European development plans, one of the key priorities is to preserve a sustainable and friendly environment for future generations. Achieving climate neutrality is central to this mission, yet progress depends heavily on the availability of reliable data that capture not only historical and sectoral trends but also the dynamics of societal behaviour. This paper addresses the challenge of data acquisition as a preparatory step for feeding a climate neutrality simulation model. Established databases provide extensive quantitative information on energy use, emissions, production, and consumption patterns, offering a solid foundation for modelling long-term technological and economic transitions. However, such sources remain insufficient for representing behavioural aspects that critically influence the speed and direction of transition pathways. To bridge this gap, we designed a systematic approach to collect complementary data on societal behaviour. Particular emphasis was placed on identifying thresholds at which collective habits, practices, and attitudes begin to shift in response to environmental challenges and policy interventions. The findings highlight the importance of combining heterogeneous data sources to better reflect socio-technical realities. Such an integrated dataset not only strengthens the foundations for climate neutrality simulation models but also enhances the potential of evidence-based policy design. Ultimately, the work contributes to developing more realistic and actionable transition pathways, ensuring that climate neutrality strategies align with both technological capabilities and societal behaviour.

Keywords: **Climate neutrality, Data acquisition, Behavioural thresholds, Questionnaire**

ET029

FARM-LEVEL GREENHOUSE GAS EMISSION DECISION SUPPORT TOOL: MULTIPARAMETER SENSITIVITY ANALYSIS WITH SOBOL AND MORRIS METHODS

Katrīna Muižniece, Jovita Pilecka-Uļčugačeva, Inga Grīnfelde

Latvia, Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technology, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Mitigating climate change demands action across sectors and down to the organizational level. Agriculture, as one of the largest contributors to greenhouse gas (GHG) emissions, plays a significant role in climate change and therefore requires a complex GHG emission reduction, starting from farm level. To support and accelerate farm level GHG emission reduction, digital decision support tools (DST) developed specifically for this reason play a crucial role. To ensure the reliability and accuracy of the tools, a thorough validation of the developed tools is required. This study aims to rigorously validate a farm-level GHG accounting and decarbonization DST by applying Sobol' and Morris global sensitivity analyses to assess output robustness and identify the most influential input parameters for reliable mitigation planning. Validation of this DST was performed using two validation methods – Sobol' and Morris – ensuring comprehensive evaluation of tools robustness as well as identification of the tools parameters with the highest influence on the farm level GHG emission results. The validation results demonstrate that the tool provides consistent outcomes across different sensitivity analysis approaches, strengthening confidence in the tool's application for supporting emission reduction planning and offering a methodological basis for future improvements and broader applications in agriculture. These results support the DST's suitability for prioritizing mitigation actions and planning emission-reduction pathways at the farm scale. The work also provides a transparent methodological template for validating agricultural DSTs and highlights parameters where improved data collection would deliver the greatest gains in accuracy, informing future tool refinements and broader applications in agriculture.

Keywords: **GHG emissions, Decision support tool, Sensitivity Analysis, Agriculture decarbonization**

ET030

DIVERSITY OF AEROSOL CLASSIFICATION ALGORITHMS FOR SOURCE APPORTIONMENT PURPOSES

Vikija Kupča, Iveta Šteinberga

Latvia, University of Latvia (LU)

The classification of atmospheric aerosol types is a critical step for source apportionment, directly impacting the accuracy of air quality forecasting and climate modeling. This task is often limited by the rigidity of traditional threshold-based algorithms, which rely on a fixed set of rules that struggle to capture the complex variability of real-world aerosol mixtures. This challenge is compounded by frequent data gaps in ground-based networks, such as unavailable Single Scattering Albedo (SSA) measurements, a key parameter for distinguishing absorbing from non-absorbing aerosols. This study investigates how different families of algorithms perform under these challenging conditions. We conduct a systematic comparison of a classic threshold-based method against multiple of data-driven machine learning (ML) models, including methods like (Random Forest), kernel-based models (Support Vector Machines), and simpler linear classifiers. Using a multi-year AERONET dataset from Lampedusa as a benchmark, a site known for its complex mixture of Saharan dust, marine spray, and European pollution, all models were trained on the same set of readily available optical inputs: primarily Aerosol Optical Depth (AOD) and Angstrom Exponent (AE). The physical validity of each method's output was confirmed using independent in-situ chemical tracer data, such as Aluminum (Al) for dust and Sodium (Na) for marine aerosols. The analysis demonstrates that flexible, data-driven models that can learn non-linear relationships more effectively capture the nuanced variability of aerosol mixtures. In particular, the Random Forest model proved highly adept at distinguishing between pure and mixed aerosol types, a finding strongly corroborated by the chemical validation. This work provides a clear framework for advancing aerosol classification beyond classic threshold-based methods, enabling more reliable and scalable source apportionment.

Keywords: **Aerosols, Source apportionment, Environmental monitoring**

ET031

SYSTEM DYNAMICS MODEL FRAMEWORK FOR SUSTAINABLE DEVELOPMENT AND ITS ANALYSIS

Oskars Kaļva, Iveta Šteinberga

Latvia, University of Latvia (LU)

Sustainable development has become a strategic imperative for companies that are operating in various industries, where the balance between economic growth, environmental stewardship, and social responsibility is increasingly scrutinized. The complexity of sustainability challenges at the corporate level – encompassing greenhouse gas emissions reduction, energy efficiency, innovation investment, and stakeholder trust – requires analytical frameworks that move beyond linear or static approaches. System dynamics with its foundations in feedback structures and stock–flow representation (Forrester, 1961; Sterman, 2000), provides a powerful methodology to capture interdependencies, delays, and non-linear effects that shape company`s long-term sustainability trajectories. In the business context, system dynamic can be applied to model corporate environmental strategies (González et al., 2018), supply chain sustainability (Georgiadis & Besiou, 2012), and the diffusion of cleaner technologies. The integration of corporate sustainability assessment frameworks, such as ESG reporting standards, with system dynamic modelling enables companies to test alternative policies and evaluate trade-offs across environmental, social, and economic dimensions (Barbosa et al., 2023). This publication proposes to create system dynamics model and framework for sustainable development at the company level, designed for decision-makers. The framework aims to link sustainability standards and corporate strategies with system feedback structures, provide simulation-based experimentation with investment, innovation, and operational policies and questions, and assign company-level decisions with broader sustainable development goals. By establishing system dynamics into corporate sustainability management, companies can improve strategic foresight, identify leverage points, and design robust policies for long-term value creation in a resource-constrained environment.

Keywords: **Sustainabilty, system dynamics, modelling**

ET036

SUSTAINABLE SOLUTIONS: ALUMINUM RECOVERY FROM WASTEWATER USING FLUIDIZED-BED HOMOGENEOUS CRYSTALLIZATION POST-DELAMINATION OF MULTILAYER FLEXIBLE PACKAGING

Agne Sleiniute, Ha Thi-Hanh, Gintaras Denafas, Ming-Chun Lu

Lithuania, Kaunas University of Technology (KTU), Taiwan, National Chung Hsing University

The increased use of multilayer flexible packaging, valued for its protective qualities and cost-effectiveness, presents significant challenges in waste management due to the difficulty of separating its material layers. Traditional recycling methods often fail to process these materials effectively, resulting in more waste being sent to landfills or incinerated. This study examines emerging recycling technologies, with a focus on delaminating aluminum-polymer composites and managing the resulting wastewater. While generally safe, aluminum can pose health risks at high levels, making its removal from wastewater essential. Traditional methods like reverse osmosis and cation exchange are effective but expensive. Fluidized-bed homogeneous Crystallization (FBHC) is a promising alternative, turning chemical precipitation sludge into reusable dense granules. This study evaluates FBHC's effectiveness in treating aluminum-rich wastewater from the delamination process, highlighting its environmental and economic benefits. The environmental impacts of FBHC were assessed using the Environmental Footprint (EF) 3.1 method, which normalizes and weights various impact categories. The software SimaPro 9.5.0.2 (PhD) was used for the life cycle assessment (LCA) studies. Key findings show that FBHC has a lower overall environmental impact than incineration and landfill methods, especially in categories like freshwater ecotoxicity and climate change. Fluidized Bed Homogeneous Crystallization (FBHC) is an effective and environmentally friendly method for recovering aluminum from wastewater, offering significant advantages over traditional waste treatment methods.

Keywords: **Fluidized, Bed Homogeneous Crystallization, Aluminum recovery, multilayer food packaging**

ET037

OCCURRENCE OF NON-TIMBER FOREST PRODUCTS IN LATVIA: EVIDENCE FROM THE NATIONAL FOREST INVENTORY

Agita TREIMANE, Zane Lībiete, Elferts Didzis, Jānis Donis

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava), Latvia, Forest and Wood Products Research and Development Institute (MeKA)

In recent years, increasing emphasis has been placed on the multiple functions of forest ecosystems and the broad range of goods and services they provide. In line with the EU Forest strategy, sustainable forest management also requires ensuring the continuous and sustainable availability of non-timber forest products (NWFPs). To assess the long-term availability of NWFPs, systematic monitoring is essential. Such assessments make it possible to identify which stand parameters, species compositions, and soil properties are most important for individual species. By understanding the ecological requirements of each species, it becomes possible to predict their future occurrence in Latvia, considering the impacts of climate change and specific forest management practices. This study summarizes data on the monitoring of non-timber forest resources in Latvia, conducted on a subset of National Forest Inventory sample plots under hemiboreal forest conditions characteristic of the country. The study aimed to evaluate various species — lingonberries, bilberries, bog bilberries, cranberries, cloudberries, wild raspberries, wild strawberries, black crowberries, heather, and lichens — across different forest types. Data collection took place from 2019 to 2023 on nearly 8,000 permanent sample plots. In each forest stand, a 3 × 3 m plot was established, where the projective cover of each species was recorded. In Latvia, located in the hemiboreal vegetation zone, forest stands are largely composed of a mixture of coniferous and broadleaved tree species. However, the most frequently observed and widespread NWFP species were bilberry (~25% of plots) and lingonberry (~20%), both strongly associated with conifer-dominated stands. Wild raspberry ranked third in frequency, while other species were much rarer. These findings highlight the uneven distribution of NWFPs in Latvian forests and the dependence of species on specific stand types, age, and tree species compositions.

Keywords: **Non, wood product, monitoring, forestry**

ET038

FROM CHIPS TO CHEMICALS: UPGRADING CONIFER GREENERY TO BIOPHARMA, COATINGS AND AGRICULTURAL INPUTS

Mārcis Mezulis, Lauris Arbidans, Maris Lauberts, Maris Klavins

Latvia, University of Latvia (LU), Latvia, Latvian State Institute of Wood Chemistry, Latvia, environmental science dept., university of latvia

In Latvia, forests cover 53% of the territory (3.412 mil. ha) and significantly contribute to the economy, accounting for 6.5% of GDP and 22% of exports in 2024. Conifers dominate Latvian forests (55%), of which 30% are pine and 25% spruce, providing broad availability of greenery (branch and needle biomass). In 2023 alone, 17 400 m3 of wood were harvested in Latvia. Across the Baltics, forest area reaches 7.794 mil. ha, representing one of the largest biomass resources. Greenery biomass constitutes 30-50% of tree biomass and yields 100-120 kg of greenery per cubic meter of spruce logs that is chipped and burned for heat in thermal power plants, producing low value-added outputs. This work promotes an integrated biorefinery of spruce and pine greenery using solvents that are friendly to the environment and human health, converting forestry by-products into high value-added products. A spruce and pine greenery biorefinery could produce high value-added extract fractions: waxes for hydrophobic coatings; polyphenol, polyprenol and abietate fractions for biopharmaceutical applications with anti-inflammatory potential. Using extracted biomass, it is possible to create two new product schemes: hydrothermal biomass processing and the creation of biodegradable materials for agricultural needs. Using hydrothermal carbonization (HTC) in an alkaline environment, it is possible to obtain artificially produced humic substances as plant growth stimulants, or in an acidic environment, it is possible to obtain hydrochar and later also activated charcoal with the potential for heavy metal and drug adsorption. Biodegradable materials could potentially be modified with artificial humic substances, micro and macro elements that would improve plant growth conditions. Such a full-cycle, zero-waste process strengthens the circular bioeconomy, reduces the amount of biological waste generated, and increases the return of carbon to natural cycles.

Keywords: **Conifer greenery, integrated biorefinery, circular bioeconomy, zero, waste, forestry sidestreams, green solvents**

ET039

HEALING THE LAND: ECO-FRIENDLY SOIL RECLAMATION AND SUSTAINABLE RECOVERY IN POST-WAR UKRAINE

Valeriy Mykhaylenko, Mykola Blyznyuk, Ruslan Havrylyuk

Ukraine, Kyiv Medical University

Ukraine, a major global exporter of grain and oilseed crops, faces an escalating ecological crisis due to the contamination of agricultural lands with persistent organic pollutants (POPs). These pollutants, often released unintentionally during military conflicts—especially through open fires and destruction of infrastructure—pose long-term risks to soil health, food safety, and public well-being. Despite the severity of the issue, public awareness remains critically low, and the creeping nature of POPs pollution threatens Ukraine's progress toward its Sustainable Development Goals (SDGs), particularly those related to health, food security, and climate action. The transboundary implications are profound, as contaminated Ukrainian exports could impact vulnerable populations in importing nations, especially in Africa and Asia. In response, the National Ecological Centre of Ukraine (NECU), in collaboration with leading universities, has launched the Carpathian School initiative to educate youth and local communities on phytoremediation—a cost-effective, scalable, and environmentally friendly method of soil purification using plants. This initiative aligns with the Stockholm Convention on POPs and emphasizes the transfer of European technologies to Ukrainian contexts. By integrating education, community engagement, and scientific research, the project aims to build resilience against environmental degradation and foster sustainable land management practices in post-war Ukraine. The abstract highlights the urgent need for coordinated action, public awareness, and international support to mitigate the long-term consequences of POPs contamination and restore Ukraine's agricultural landscapes

Keywords: **Persistent Organic Pollutants POPs, unintentional emission, phytodegradation, Carpathian School**

ET040

DISTRIBUTION, MORPHOLOGY AND FORMATION CONDITIONS OF INLAND DUNES IN THE EASTERN PART OF THE CENTRAL LATVIAN LOWLAND

Juris Burlakovs, Maris Krievans, Liana Znudova, Zane Vincevica-Gaile

Poland, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Latvia, University of Latvia (LU)

Research explores the origin, distribution, and morphology of inland dunes in the eastern part of the Central Latvian Lowland, a region where ancient aeolian landforms lie far from the modern Baltic Sea coast. These dunes began forming during the cold and arid late Weichselian glacial stage, when extensive glacial meltwater basins dominated the landscape. Their spread is largely connected with former outwash plains, yet their exact extent, age, and relationship to palaeoshorelines have remained poorly known. Previous studies offered only fragmentary or speculative views and no detailed large-scale maps existed. The study combined high-resolution geomorphological mapping, field measurements of aeolian sediment stratification, and optically stimulated luminescence (OSL) dating of sand samples. A comprehensive spatial analysis produced a new distribution map showing the position and morphology of dunes between the Gauja and Lielupe rivers and clarified their relation to ancient basin shorelines. Results indicate that inland dune formation started later than traditionally assumed - during the early Younger Dryas and continuing into the Preboreal period, when improved natural drainage allowed wind-driven sand transport independent of the retreating meltwater coasts. The research also considers present-day implications - most dunes are now forested and inactive, ongoing deforestation, increasing climatic continentality and global warming could re-activate aeolian processes, as occurred in Latvia from the late 18th century until the 1930s. By providing precise morphological data and temporal context, this work significantly advances understanding of postglacial landscape evolution in Latvia and offers a solid foundation for future investigations of aeolian dynamics under changing environmental conditions.

Keywords: **aeolian sediments, parabolic dunes, wind palaeodirections, OSL ages, ancient shorelines**

ET041

INFLUENCE OF GLACIGENIC SEDIMENT FORMATION ON COMPRESSIBILITY AND CONSOLIDATION BEHAVIOUR: LABORATORY TESTING AND NUMERICAL MODELLING

Juris Burlakovs, Maris Krievans, Laura Pundure, Liga Salmina, Zane Vincevica-Gaile, Juris Macans

Poland, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Latvia, University of Latvia (LU), Latvia, Riga Technical University (RTU)

The research investigates how glacigenic sediment formation controls the compressibility and consolidation settlement of tills, integrating laboratory geotechnical testing with numerical modelling of a railway embankment. Glacigenic soils are products of subglacial deposition where water, coarse, and fine particles interact through consolidation, shear deformation, and dilatancy, processes that govern compressibility, filtration, and shear strength. Their heterogeneity and mixed composition require that classical soil mechanics be combined with glacial geology to understand the link between past formation conditions and present engineering properties. A key parameter is the preconsolidation stress, which, expressed as the over-consolidation ratio (OCR), reflects the maximum historical effective stress and strongly influences deformation and settlement predictions. Compressibility parameters and preconsolidation stresses were determined using several analytical methods to evaluate OCR variations across the study area. Parallel numerical modelling with Settle3 simulated consolidation settlement beneath a railway embankment, employing different consolidation coefficient values derived from the laboratory tests. Continued field monitoring beyond 90 days confirmed that the time required for full consolidation depends strongly on soil type and geological history. By linking subglacial depositional environments to modern mechanical behaviour, the study highlights the need to incorporate glacial geological principles when predicting settlement of over-consolidated tills in engineering projects and provides guidance for selecting appropriate laboratory methods and modelling approaches under varying geological conditions.

Keywords: **tills, effective stress, overconsolidation, preconsolidation stress, soil settlement, oedometer**

ET042

ANALYSIS OF SOIL CONTAMINATION WITH HEAVY METALS AS A RESULT OF HOSTILITIES IN UKRAINE

Denys Maslov

Ukraine, National University of Kyiv-Mohyla Academy

The study presents the results of the analysis of soil contamination with heavy metals and combustion compounds as a result of hostilities in Ukraine, in areas that have experienced active military actions in the territory of the settlement of Mala Tokmachka, Zaporizhia region. The research focuses on the detection of polluting elements as a result of artillery shelling and explosions. Soil contamination was investigated for elements including lead (Pb), manganese (Mn), chromium (Cr), arsenic (As), vanadium (V), iron (Fe), zirconium (Zr), tin (Sn), magnesium (Mg), cobalt (Co), nickel (Ni), bismuth (Bi), copper (Cu), strontium (Sr), lithium (Li) and antimony (Sb) and other elements and compounds. The results clearly indicate that the pollution was due to anthropogenic impact from hostilities. Active military operations lead not only to significant human losses and destruction of infrastructure, but also to profound and long-term ecological changes, the consequences of which can persist for decades. High-intensity hostilities exert complex anthropogenic pressure on the environment and the functioning of ecosystems. The use of heavy military equipment, in particular tanks and armored vehicles, as well as large-scale explosions and artillery shelling cause mechanical, chemical, and physical degradation of soils (Solokha et al., 2024). The armed aggression of the Russian Federation against Ukraine, which ranks among the largest military conflicts since World War II, began in February 2014, with the occupation of the Crimean Peninsula. In areas of active combat, multiple launch rocket systems (MLRS) are widely used, including BM-21 Grad, BM-27 Uragan, BM-30 Smerch, Tornado-S, and TOS-1A Solntsepok heavy flamethrower systems. They are capable of hitting large areas with a single volley. The ammunition used by these systems contains high concentrations of toxic elements: zinc, copper, barium, iron, nickel, magnesium, as well as sulfur as a by-product of combustion.

Keywords: **Soil contamination, Military activity, War, induced environmental impact, Heavy metals, Pyrotechnic pollutants**

ET043

ENVIRONMENTAL CHALLENGES OF FUTURE AERODYNAMICS

Audrius Jonušas, Esmeralda Styps

Lithuania, Kaunas University of Applied Engineering Sciences (KTK)

The field of aerodynamics faces a range of environmental challenges in the future as the demand for faster and more fuel-efficient aircraft increases. As aviation continues to grow, the pressure to minimize its environmental footprint becomes more urgent, particularly given the industry's contribution to greenhouse gas emissions. In order to address these challenges, researchers and engineers are developing innovative technologies such as electric propulsion systems, biofuels, and advanced materials to improve the efficiency and sustainability of aircraft. Additionally, improvements in aerodynamic design, lightweight structures, and air traffic management systems are being explored to reduce emissions, fuel consumption, and noise levels. Overall, the future of aerodynamics will require a holistic approach that considers the environmental impact of aviation and strives to develop cleaner and greener technologies to ensure a sustainable future for air travel. Through continued collaboration and innovation, the industry can work toward achieving net-zero emissions and reducing its ecological footprint. This transformation will also depend heavily on cross-sector collaboration, involving not only aerospace manufacturers but also governments, regulatory bodies, and energy providers. Furthermore, public awareness and consumer demand for greener travel options are likely to influence the pace and direction of industry changes. Education and workforce development will be essential to prepare the next generation of engineers and scientists to tackle the complex challenges ahead. As the field evolves, integrating environmental considerations into every stage of aircraft design and operation will be key to shaping a cleaner, more responsible future for aviation.

Keywords: **aerodynamics, fuel, efficient, carbon emissions, electric propulsion systems, sustainability of aircraft**

ET044

APPLICATION OF A DIGITAL TERRAIN MODEL FOR ACCURACY ASSESSMENT OF DRAINAGE SYSTEMS

Jolanta Celma, Vivita Pukite, Armands Celms

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Institute of Land Management and Geodesy, Latvia, ZIGI

The beginning and use of remote sensing technologies is considered to be the 19th century, when the first photographs were taken in Paris. This was the first time that photography from a hot air balloon was defined as remote sensing. Previously, carrier pigeons, kites, and rockets were also used. Since then, remote sensing technologies have developed significantly with much more modern devices – aerial photographers, aerial laser scanners. Remote sensing technologies play an important role in modern geophysics, geography and surveying, as well as in other earth sciences. They have significant advantages, such as wide geographical coverage, real-time data, access to hazardous or inaccessible areas, multi-angle and multi-spectral imaging, and the ability to analyze existing data and cross-reference it with acquired data, resulting in data that is analyzed, updated and up-to-date. The data on drainage systems have been updated from plans and measurements of historically constructed drainage systems, which were depicted on large-scale maps that are very opaque and difficult to read. With the development of more modern technologies, the plans of drainage systems were digitized and merged into a public national information system called the Reclamation Cadaster Information System. The Reclamation Cadaster Information System contains both textual data, containing information on the qualitative and quantitative condition and status of drainage systems, and spatial data, containing cadastral plans, executive surveys and maps in analogue and digital form. The research compared data from historically constructed and modern rehabilitated drainage systems with data from remote sensing technologies. The research included 18 drainage structures - drainage wells. The aim of the research was to find out whether it is possible to pinpoint the location of drainage wells in the terrain using a digital terrain model.

Keywords: **remote sensing, digital terrain model, drainage system, drainage wells, LIDAR data**

ET045

INTEGRATING BIOINDICATION AND SNOW CONTAMINATION ANALYSIS FOR LONG-TERM ASSESSMENT OF URBAN AIR QUALITY: A SEVEN-YEAR STUDY OF HEAVY METAL POLLUTION DYNAMICS IN JELGAVA, LATVIA

Jovita Pilecka-Ulcugaceva, Inga Grīnfelde

Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Urban air quality is a growing concern globally, particularly in cities where over half of the world's population resides, with urbanization rates expected to rise further. In Latvia, approximately 70% of the population lives in urban areas, where air pollution poses significant health and environmental challenges. This study investigates the dynamics of heavy metal pollution in Jelgava, Latvia, through the development of an innovative methodology that integrates bioindication techniques with snow contamination analysis. For the first time in Europe, this research provides a continuous seven-year dataset (2018–2024) on the accumulation of heavy metals in urban snow, offering a high spatial resolution of 1 km² across the city. Key findings indicate significant spatial variability in concentrations of heavy metals such as zinc (Zn 0.007–1002.1 µg/L), copper (Cu 0–829.50 µg/L), nickel (Ni 0.0005–40.40 µg/L), and lead (Pb 0.7–62.97 µg/L). Statistical analyses, including Kruskal-Wallis tests, reveal transport corridors as critical contributors to air pollution, with statistically significant variations ($p < 0.0001$) observed across distance groups. The study underscores the complexity of urban air pollution, emphasizing the need for comprehensive monitoring frameworks that integrate long-term and short-term data, advanced spatial analyses, and cross-disciplinary approaches. The findings are pivotal for identifying pollution sources, assessing spatial risks, and guiding the development of urban planning and policy frameworks for sustainable city management. This research contributes to the global discourse on urban air quality, offering a replicable model for assessing and mitigating air pollution in complex urban environments.

Keywords: **biomonitoring, lichen, based monitoring, Air Purity Index, urban sustainability**

ET046

THEORETICAL POTENTIAL OF ROOFTOP RAINWATER HARVESTING FOR AGRICULTURE: LITHUANIAN CASE STUDIES

Gitana Vyciene, Vilda Grybauskiene, Inga Grinfelde

Lithuania, Kaunas University of Applied Engineering Sciences (KTK)

Agricultural water demand in Lithuania is rising, while increasing climate variability and uneven rainfall distribution are intensifying seasonal water shortages. Many small and medium-sized farms lack access to reliable irrigation sources, making them vulnerable to prolonged dry spells. Identifying alternative supplementary water resources is therefore critical to enhance farm resilience and reduce dependence on groundwater and surface water alone. The study aims to assess the theoretical potential of rooftop rainwater harvesting (RWH) as a supplementary water source for agriculture in Lithuania and to determine optimal tank sizes under different precipitation scenarios. Case studies were conducted on private farms in Degučiai, Mitkūnai, and Alukėnai villages. Ten years of precipitation data from nearby meteorological stations were analyzed. Water demand during the vegetation period was based on farm-specific irrigation requirements. RWH potential and tank sizing were evaluated using established runoff and water balance assumptions. Across the three case studies in Mitkūnai, Degučiai, and Alukėnai farms, rainwater harvesting efficiency was strongly influenced by precipitation, roof area, and water demand, with tank size being the key limiting factor. Small catchments (50–100 m²) supplied only 22–24% of demand in dry years, and increasing tank capacity alone brought little improvement, as inflow was insufficient. Expanding the catchment to 200 m² substantially increased effectiveness, meeting up to 43% of demand in dry years and 65% in wet years. Optimal tank sizes ranged from 11–14 m³ for small catchments and 14–53 m³ for larger ones. While rainwater harvesting cannot fully meet farm needs, it provides a valuable supplementary source under varying climatic conditions.

Keywords: **rainwater harvesting, agriculture, precipitation variability, rooftop catchment, tank sizing**

ET047

PFOS AND PFOA AS PFAS MICROPOLLUTANTS IN THE DAUGAVA RIVER: MONITORING AND REGULATORY PERSPECTIVES

Jana Grave, Inga Grinfelde, Jovita Pilecka-Uļčugačeva, Paula Miezaka

Latvia, Liepaja University, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Micropollutants, including per- and polyfluorinated alkyl substances (PFAS), are increasingly recognized as a major pressure on European surface waters. Due to their extreme persistence, mobility, and toxicity at low concentrations, PFAS are practically non-degradable in the environment. Among them, perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are of particular concern, given their widespread anthropogenic origin and well-documented risks to aquatic ecosystems and human health. In the European Union, water policy has recently strengthened its focus on PFAS. The Environmental Quality Standards Directive (2008/105/EC, amended by 2013/39/EU) sets an annual-average EQS for PFOS of 0.65 ng/L (0.00065 µg/L) in inland surface waters and 0.13 ng/L (0.00013 µg/L) in coastal/transitional waters, with a primary biota EQS of 9.1 µg/kg (wet weight). Ongoing 2023 revisions of the Water Framework Directive aim to expand monitoring and update thresholds for broader PFAS groups. These developments underscore the need for reliable data to assess compliance and guide water management. This study analyzes publicly available short-term monitoring data from Latvian Environment, Geology and Meteorology Centre (LVGMC) stations along the Daugava River, where PFOS and PFOA have been measured intermittently. While the available dataset does not allow long-term trend analysis, it provides valuable insights into the presence of these compounds in one of the largest rivers in the Baltic region. PFAS in the Daugava arise from anthropogenic sources (foams, cookware, textiles, packaging, cosmetics, plating, electronics), yielding diffuse and long-lived contamination. The findings underscore the importance of continuous monitoring, harmonization with EU standards, and the development of effective treatment and management strategies to mitigate PFAS-related risks in Latvia's surface waters.

Keywords: **PFAS, PFOS, PFOA, micropollutants, Daugava River, surface water, anthropogenic sources, EU regulation, monitoring**

ET048

STUDY OF THE IMPACT OF MECHANICAL PROPERTIES OF METALLIC MATERIALS AND SURFACE TREATMENT TECHNOLOGIES ON OPTIMIZING MATERIAL APPLICATIONS IN AIRCRAFT STRUCTURES

Esmeralda Styps, Valdas Speičys

Lithuania, Kaunas University of Applied Engineering Sciences (KTK)

M14-P modification engines are used in aircraft intended for sports, agriculture, auxiliary aviation and mainly in JAK type aircraft. When repairing the M14-P engine and replacing its components it is necessary to assess the strength properties of the material from which these elements are made, taking into account the operating conditions. The hardness of a metal is a measure of the metal's ability to resist permanent indentation or deformation of the metal's surface when an indenter forms an indentation under load. The hardness and strength of a metal depend on the movement of dislocations through the metal, which create the conditions for deformation to occur. Without dislocations, metals would be very brittle and would crack or fracture when the stresses created exceeded the metal's strength. The results of hardness tests are influenced by many factors: the position of the testing device and the table, the lighting settings during the test, and the calibration of the testing device. Most often, it is limited to the results of the hardness test. However, this is not enough to properly assess the strength properties of the sample material, taking into account the area of application. In order to systematize and group the test measurement parameters, this study focuses on optimizing the determination of measurement parameters by evaluating the indentation diameters and their relationship with hardness indicators. The study, using our developed algorithm for determining hardness/resistance measurement parameters, found that the M-14P engine: the piston pin is made of steel, and the intake and exhaust valve guide bushings are made of bronze. The galvanizing process has influenced the strength properties of the intake and exhaust valve guide bushings of the M-14P engine. The galvanized layer forms a special metallurgical structure that can withstand mechanical damage during use.

Keywords: **M14, P modification engines, hardness tests, hardness, resistance measurement parameters, galvanizing process**

ET049

THE PROBLEM OF WATERLOGGED AND ABANDONED LAND AREAS IN LITHUANIA

Vilma Šalkauskienė

Lithuania, Lietuvos Inžinerijos Kolegija Higher Education Institution

Agriculture is one of the most important sectors of the economy, ensuring food production, employment, and regional development. Today, agriculture faces numerous challenges, the most significant of which is adaptation to climate change. In Lithuania, an increasingly observed issue is the non-use of land for its intended purpose, manifested through the expansion of abandoned and waterlogged areas. Abandoned land is often defined as territory that was once actively used but, for various reasons, no longer performs its primary function. In Lithuania, the concept of abandoned land is closely linked to fallows and renaturalization. According to the Lithuanian Land Resource Monitoring System, in 2024 abandoned agricultural land covered about 32,914 hectares, showing a continuous increase. Waterlogging is determined by climatic conditions, heavy rainfall, relief characteristics, and climate change–induced extreme events such as floods or intense rains. Meanwhile, land abandonment arises due to social and economic changes, particularly in remote regions where declining populations and the withdrawal of farming reduce the economic potential of agricultural land. Both processes pose threats to agricultural productivity, biodiversity, landscape quality, and regional vitality, making their resolution highly important in the context of sustainable development, food security, and environmental protection. The application of modern technologies for water management and land monitoring remains limited, while legal and economic mechanisms for integrating abandoned plots into active land use systems are not sufficiently effective. Such land mismanagement reduces the competitiveness of the agricultural sector, increases environmental challenges, and contributes to the social and economic stagnation of rural regions.

Keywords: **derelict land, land use, waterlogged land areas**

ET050

PARAMETER REGIONALISATION FOR THE METQ MODEL IN THE LAKE-RICH MALTA RIVER BASIN

Anda Bakute, Inga Grīnfelde, Jovita Pilecka-Uļčugačeva

Latvia, Scientific Laboratory of Forest and Water Resources, Latvia University of Life Sciences and Technologies, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Hydrological modelling in ungauged catchments is constrained by the absence of discharge observations, which prevents direct calibration of model parameters. In such cases, parameter regionalisation is applied to transfer information from gauged to ungauged basins. This challenge is particularly relevant in Latvia, where many small river basins are characterised by a high proportion of lakes. Lake-rich basins introduce complexity, as runoff is delayed and peak flows are attenuated by the storage of lakes. The aim of this study was to develop and evaluate a parameter regionalisation approach for the conceptual hydrological model METQ in a lake-rich catchment. The Malta River basin, a representative example in eastern Latvia, was selected as a case study. The Hydrographical Response Unit (HRU) approach was applied by classifying basins according to physiographic and land-use characteristics, with lakes treated as a distinct HRU type. Regionalised parameter sets from previously calibrated basins were evaluated against observed discharge using Nash–Sutcliffe efficiency (NSE), percent bias (PBIAS), and correlation coefficient (r). Regionalised parameters reproduced the seasonal water balance and the buffering effect of lakes with satisfactory accuracy. However, limitations were observed under extreme conditions, as peak flows were underestimated and rapid runoff responses were not fully captured. Sensitivity analysis indicated that KU (upper limit of the evapotranspiration coefficient) and ZCAP (capillary rise height) were among the most influential parameters in the Malta basin. The results underline the importance of explicitly incorporating lake influence into regionalisation frameworks. Although the study was limited to one basin, the findings provide insights for extending conceptual modelling to ungauged lake-rich basins and suggest directions for improving parameter robustness under extreme events.

Keywords: **METQ, parameter regionalisation, HRUs, lake, rich catchments, Malta River, Latvia**

ET051

ASSESSING THE ENVIRONMENTAL IMPACT OF BIO-BASED MATERIALS AND PRODUCTS: CHALLENGES AND OPPORTUNITIES

Jolanta Dvarionienė, Shovkat Gojaeva

Lithuania, Kaunas University of Technology (KTU)

The urgent need to reduce resource depletion, carbon emissions, and environmental damage is driving major changes in the chemical sector. The primary goals of policy initiatives such as the Green deal and the bioeconomy are to separate economic growth from resource consumption by promoting climate neutrality, clean energy, resource efficiency, circularity, pollution reduction, and biodiversity preservation . Bio-based materials which are made from renewable resources like crops, forestry residues, or organic waste have drawn more attention. They lessen reliance on products made from fossil fuels and create new opportunities for energy-efficient chemical transformations, wastewater treatment, and other processes. Bio-based materials sustainability is depends on a number of important criteria, such as the amount of land and water used, the energy used during processing, and etc. There may be trade-offs in some situations, such as reduced carbon emissions but increased strain on soil health or biodiversity. A vital technique for assessing these effects fairly, from resource extraction to product disposal, is life cycle assessment (LCA). Developments in bio-composites, biodegradable packaging, and cutting-edge recycling technologies, along with sector-to-sector cooperation and governmental assistance, can establish bio-based and biologically derived products as important facilitators of a resource-efficient and climate-friendly economy. In this paper the main research aim was to review the methods and strategies suitable for the environmental impact assessment of the bio-based materials and products. the review explores both the challenges and opportunities of assessing their environmental impact, highlighting pathways to guide sustainable innovation. This work was supported by the LivMat project “title” (No.S-M-ERA.NET-24-1) funded by the Lithuanian Science Board through the M-ERA.NET Programme call 2023.

Keywords: **Environmental impact assessment, bio, based materials, Life cycle assessment LCA, renewable resources**

ET052

EVALUATING THE POTENTIAL OF NATURAL PHOSPHORUS-ENRICHED SORBENTS IN PEAT-BASED MEDIA FOR SUSTAINABLE FLORICULTURE

Dagnija Grabuža, Rūta Ozola-Davidāne, Linda Grinberga

Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Phosphorus (P) is an essential, non-substitutable nutrient critical for global food production; however, its supply within the European Union remains highly import-dependent. In recognition of its strategic importance, phosphate rock and P were classified as Critical Raw Materials. At the same time, excessive P discharge, particularly from untreated or insufficiently treated wastewater, continues to contribute to eutrophication, especially in rural or decentralized regions lacking advanced treatment infrastructure. The recast Urban Wastewater Treatment Directive (EU) 2024/3019 introduces stricter P removal requirements for agglomerations as small as 1000 population equivalents and promotes nutrient recovery and reuse, particularly through agricultural applications. These dual challenges of resource scarcity and environmental impact highlight the urgent need for cost-effective, innovative solutions that integrate P removal with circular nutrient reuse. P is also a vital macronutrient for plant development, yet current fertilizer sources are derived from finite, non-renewable resources. P-rich precipitates produced during wastewater treatment are often disposed of in landfills, offering no long-term benefit. A promising alternative is the use of sorbent materials that capture P during treatment and can later be reused as fertilizers, provided the P remains plant-available and safe. This paper presents a literature-based evaluation to support the development of a research methodology for testing P-enriched sorbents in peat-based growing media for ornamental bedding plants. The proposed research aims to assess plant growth responses, nutrient uptake, and substrate quality while evaluating the potential to reduce commercial fertilizer use and to promote sustainable floriculture practices. Acknowledgements: This research is supported by the Interreg Estonia-Latvia project NutriLoopWorks (EE-LV00163) and the Interreg Central Baltic project ReNuW-Hubs (CB0700318).

Keywords: **Phosphorus recovery, Natural sorbents, Ornamental plants, Circular nutrient use**

ET053

CLIMATE RISKS AND SECURITY POLICY: THE ROLE OF LAW IN ENHANCING THE RESILIENCE OF LAW ENFORCEMENT STRUCTURES

Kseniia Zaitseva, Svetlana Boychenko

Ukraine, Scientific institute of public law, Ukraine, National University of Kyiv-Mohyla Academy

Climate change increasingly manifests not only as an environmental or economic issue but also as a security challenge that requires systemic responses in the fields of policy and law. The growing number of extreme weather events, large-scale migration processes, threats to critical infrastructure, and emerging forms of crime in crisis situations demand greater preparedness of law enforcement agencies. Law plays a decisive role in shaping the system of climate security. At the international level, the Paris Climate Agreement, the European Green Deal, as well as EU directives and regulations provide the framework for integrating climate policy into the security sector. For law enforcement institutions, this implies: incorporating environmental and climate law into the training programs of the Ministry of Internal Affairs and the Border Guard Service; creating effective legal mechanisms of accountability for violations in the sphere of climate and environmental security; introducing the principle of climate mainstreaming into law enforcement practice, ensuring systematic consideration of climate risks in planning, operations, and procedures. In addition to legal mechanisms, other priority steps include systematic staff training, technological modernization, development of business continuity plans, scenario planning, and investment in the psychological resilience of personnel. Thus, integrating legal instruments into security policy enables law enforcement agencies to become key actors in the system of climate security. Combining institutional, legal, technological, and human capacity-building measures will foster the creation of a comprehensive system of climate and environmental security in Ukraine, strengthen public trust, and support Ukraine's integration into the European security framework.

Keywords: **climate change, climate and environmental security, law enforcement, resilience, adaptive capacity, climate law, security policy**

ET054

JUSTIFICATION OF THE METHODOLOGY FOR DETERMINING ECOSYSTEM SERVICES OF THE KAKHOVKA RESERVOIR

Maksym Oliinyk, Victor Karamushka

Ukraine, National University of Kyiv-Mohyla Academy

The creation of the Kakhovka Reservoir, which was one of the 6 reservoirs of the Dnieper Cascade, was characterized by significant changes in the ecosystems of the Great Meadow territories. In fact, a significant (~400 km2) wetland biotope of the Dnieper Valley in the Steppe Zone of Ukraine was flooded. Since 1956, the formed Reservoir provided many benefits to the population of the arid south of Ukraine. However, on June 6, 2023, russian forces destroyed the Kakhovka Dam, leading to the destruction of the Reservoir and the loss of the products and services it provided to the region. Despite the fact that as of 2025, the front line in southern Ukraine runs along the Dnieper River, and the left-bank of the Reservoir is under the control of russian troops since its destruction, scientific discussion has continued in Ukraine regarding further steps to restore or rewild its territory. Ecosystem services (ESS) assessment is an important tool for quantifying the ecosystem potential of the Kakhovka Reservoir, which can be used when creating management plans for these areas. Valuation of ESS requires their definition. Choosing an approach to defining ESS is a critically important step in such research. For this purpose, approaches to identifying ESS based on environmental, social, risk, and other aspects and reflected in scientific publications were analyzed. The analysis of existing options became the basis for the formation of a methodological approach to defining ESS, based on environmental impacts and taking into account existing classifiers (CICES v5.2, MA, TEEB, IPBES). The list of ESS of the Reservoir formed in this way was strengthened by conducting interviews with experts. Thereby, the key feature of the proposed approach is the integration of ecosystem impact analysis, application of a classifier, and expert stress testing. As a result, a substantiated list of ESS of the aquatic and coastal ecosystem of the Kakhovka Reservoir is presented and justified.

Keywords: **Kakhovka Reservoir, ecosystem services, methodology, CICES**

ET055

SEDIMENT MICROPOLLUTANTS AND ENVIRONMENTAL INSIGHTS IN ECOLOGICAL MONITORING OF LAKE LIEPAJA

Jana Grave, Inga Grinfelde, Jovita Pilecka-Uļčugačeva

Latvia, Liepaja University, Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Lake Liepaja, a shallow lagoon-type lake in the temperate zone, faces ecological pressures from nutrient enrichment, sediment contamination, and climatic variability. This study analyzes two decades of monitoring data (2001–2023) provided by the Latvian Environment, Geology, and Meteorology Centre, focusing on the dual role of sediments as pollutant storage sites and as potential sources of remobilization. Long-term water quality records reveal persistent eutrophication, with nitrogen (1.29 mg/L) and phosphorus (0.0639 mg/L) concentrations driving a transition towards hypertrophic conditions. Elevated chlorophyll-a levels (up to 76 µg/L) indicate intensified algal blooms, while suspended solids peaked at 49 mg/L during seasonal maxima. Sediment analyses identified concerning levels of micropollutants, including heavy metals (zinc up to 19.28 µg/L, cadmium 0.118 µg/L) and persistent organic contaminants such as aldrin (0.52 µg/kg) and arsenic (1.39 mg/kg). These substances are associated with possible ecological impacts through remobilization processes and potential bioaccumulation. The findings suggest that effective management of shallow lagoon ecosystems may benefit from a dual approach: nutrient reduction and innovative strategies targeting sediment-associated micropollutants. Ecotechnological solutions, such as pollutant immobilization, enhanced sediment monitoring, and nature-based remediation, offer promising pathways to mitigate risks and strengthen ecological stability.

Keywords: **temperate lagoon, sediment micropollutants, eutrophication, ecological impacts, ecotechnological solutions, long, term monitoring**

ET056

RESILIENCE OF STEPPE ECOSYSTEMS IN SOUTHERN UKRAINE UNDER CLIMATE ARIDIZATION: A REMOTE SENSING PERSPECTIVE

Kostiantyn Klymenko, Svetlana Boychenko

Ukraine, National University of Kyiv-Mohyla Academy

Southern Ukraine has become a hotspot of aridization, with profound impacts on steppe ecosystems. Extended dry periods, recurrent droughts, and the intensification of heat extremes threaten biodiversity, soil fertility, and vegetation productivity. This study evaluates the vulnerability and resilience of two protected steppe sites - the Mykhailivskyi and Yelanets Steppes -over the period 2010–2024. We employed the Vegetation Condition Index (VCI), derived from MODIS NDVI data, to track vegetation dynamics in the growing season (April–October). The findings demonstrate that both areas oscillate between moderate stress and recovery phases. In the Mykhailivskyi Steppe, mean VCI values clustered around 50%, with notable collapses during extreme drought years (2012, 2017, 2024). Yet, recovery was observed in favorable years of 2016 and 2021, suggesting that the ecosystem retains partial resilience despite intensified climatic pressure. Similar patterns emerged in the Yelanets Steppe. Seasonal analysis revealed systematic vulnerability in late summer and autumn. Trend analysis indicates a slight but statistically meaningful increase in VCI values (+1.0–1.2% per year), pointing to gradual stabilization of vegetation cover despite episodic crises. This trend may reflect ecosystem adaptation, localized conservation efforts, or interannual climate variability. Nevertheless, the fragility of these systems underlines their sensitivity to intensifying climate extremes and highlights the urgent need for continuous monitoring. Overall, our research confirms that steppe ecosystems in southern Ukraine are at a critical threshold. They remain capable of partial recovery, but their resilience is increasingly constrained by climate extremes. Systematic remote sensing analysis, complemented by ground-based monitoring and legal instruments, is indispensable for safeguarding biodiversity and ensuring their long-term sustainability.

Keywords: **climate aridization, steppe ecosystems, vegetation stress, remote sensing, Vegetation Condition Index, ecosystem resilience**

ET057

ASSESSMENT OF ECOSYSTEM SERVICES OF FOREST PLOTS WITH VARYING CONSERVATION DEGREES WITHIN THE KHOLODNYI YAR NATIONAL PARK

Bohdan Kuchenko

Ukraine, National University of Kyiv-Mohyla Academy

The importance of classifying ecosystem services of forest ecosystem of the Kholodnyi Yar National Park was considered in the context of conservation measures planning. A general description of forest phytocenoses of the Kholodnyi Yar was prepared, based on literature analysis and field studies conducted during 2025. Based on the field studies of forest plots representing areas with different structure of phytocenoses, a detailed analysis was conducted for five forest plots with varying degrees of conservation of the natural habitat G1.A1 (EUNIS classification 2012), which is monodominant within this national park, and listed as protected according to Resolution 4 of the Bern Convention. Using the CICES classification system, a list of ecosystem services provided by each studied forest plots was compiled, and a comparative analysis of provision levels of these ecosystem services was conducted, based on differences in spatial and species structure of phytocenoses at a specific plot. In addition, the main environmental factors of negative impact on the studied plots were identified, and levels of impact of these factors on the classified ecosystem services were assessed. Using the results of this assessment, intensive forestry was identified as the main factor negatively affecting the studied forest habitat. On the second place, in terms of impact on the habitat, we placed the expansion of invasive tree species in degraded forest ecosystem, followed by aridification due to the climate change. The results of this study may be useful in planning a general list of habitat conservation measures for the Kholodny Yar National Park. However, further research is needed to analyse the peculiarities of a larger number of individual forest plots in order to plan more comprehensive measures.

Keywords: **Forest habitat, conservation degree, ecosystem services assessment, risks analysis, Kholodnyi Yar national park**

ET058

SOIL TEXTURE - DEPENDENT RESPONSES OF N2O ISOTOPIC COMPOSITION TO TILLAGE AND MOISTURE REGIMES

Dace Butenaite - Ragele, Sindija Frienberga, Jovita Pilecka-Uļčugačeva, Inga Grīnfelde

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Ainavu arhitektūras un vides inženierijas institūts

The study of greenhouse gases and the development of precise methods for their quantification are essential contributions to climate change research. Investigating nitrous oxide (N_2O), a potent greenhouse gas, across different microbiological levels of nitrogen and its compounds in soil forms the basis for an integrated understanding of climate change. By analyzing the isotopomers $\delta^{15}N\alpha$, $\delta^{15}N\beta$, and $\delta^{18}O$, and calculating derived parameters such as site preference ($\delta^{15}N\_SP$) and bulk $\delta^{15}N$ ($\delta^{15}N\_bulk$), it is possible to trace N_2O emissions to specific microbial processes. In this study, we investigated two contrasting soil types—sandy and clay soils—differing in structure and particle size distribution. Soil samples were collected from experimental plots under conventional and reduced tillage regimes. In laboratory incubations, soils were divided into aerobic and anaerobic conditions, with water applied every three days. Isotopic measurements were conducted using a Picarro G5131-i analyzer. Results indicate that the isotopic signatures in clay soils point predominantly to denitrification processes, with nitrogen isotopes becoming more enriched due to fractionation during N_2O production. Our results demonstrate that isotopomer-based approaches are indispensable for linking N_2O fluxes with underlying microbial processes, ultimately improving process-based models of greenhouse gas emissions under changing soil management practices. Furthermore, both moisture regime and tillage practice had significant effects on N_2O emissions, highlighting the importance of soil management in regulating greenhouse gas fluxes.

Keywords: **N2O Isotopomers, Picarro G5131, i, soil, tillage, moisture**

ET059

METHANE EMISSION REDUCTION IN THE LITHUANIAN ENERGY SECTOR: THE ROLE OF THE MANUFACTURING INDUSTRY

Dovidas Rubežius, Irina Kliopova

Lithuania, Kaunas University of Technology (KTU)

Methane is the second most important Greenhouse Gas (GHG) after carbon dioxide (CO2), with global warming potential about 28 times greater than CO2. According to Lithuania's National GHG Inventory document, in 2020, Lithuania generated 19.57 million tonnes CO2 eq. Methane (CH4) emission in 2020 made up 16.2% of all GHG emissions. The Energy sector is Lithuania's main GHG source. This sector generated 15,904 tonnes of CH4 in 2020 (14.1% of total CH4). The main sources of CH4 in the Lithuanian Energy sector are combustion plants within all sectors of economy (36.8%) and natural gas leakage in transmission, storage and distribution networks (over 63%). Analysis of the Lithuanian manufacturing sector's fuel-energy balance revealed that natural gas remains the main fuel source (53% in 2020, 47.5% in 2023), while biofuel use is trending upward (10.7% rise in 2023 compared to 2020). Switching to biofuels raises CH4 emissions but reduced natural gas losses lowers "non-combustion" CH4 emissions. The greatest reduction potential lies in improving energy efficiency in technological processes. For detailed analysis, the food production company UAB Plungės kooperacinė prekyba (PKP) was selected. It produces approx. 40 thousand tonnes of surimi products annually. PKP also operates boiler houses that produce approx. 70 thousand MWh of thermal energy in the form of steam. When analyzing the impact of PKP's activities on climate change (at Scope 1 and 2 levels), it was determined that in 2020 this impact reached 13,660 tonnes CO2eq, incl. 247.4 t CO2eq due to CH4. The main source of CH4 is the combustion of solid biofuel in a steam boiler. The presentation will show the results of a feasibility study of two innovations that explore the relationship between increasing energy efficiency, implementing renewable energy projects in the manufacturing industry, and reducing the impact of climate change due to CH4 abatement in the Energy sector.

Keywords: **Greenhouse Gas Emissions, Methane emission reduction, Energy efficiency**

ET060

REMEDIATING PFAS-CONTAMINATED BIOSOLIDS TO IMPROVE UTILIZATION: A REVIEW OF PHYTOREMEDIATION AND HYDROTHERMAL PROCESSING TECHNIQUES

Emiel Driessen, Henrik Haller, Erik Grönlund, Anders Jonsson

Sweden, Mid Sweden University

PFAS are a group of synthetic organofluorine chemical compounds, also called “forever” chemicals, that are produced for their stable, non-reactive properties. Their chemical inertness make PFAS largely persistent to degradation and they can thus be found in all sorts of ecosystems and in nearly all humans. Due to their toxicity to humans and other forms of life, they are increasingly seen as an environmental pollutant of primary concern. This study focuses on PFAS in biosolids from wastewater treatment. Biosolids have a high organic nutrient content which, amongst other things, make it useful as a fertilizer in forestry or agriculture. However, due to high concentrations of PFAS and other pollutants, the full utilization of biosolids as a marketable fertilizer is potentially hazardous. This study proposes an approach to valorise PFAS-contaminated biosolids by a) removing PFAS from the biosolids using phytoremediation; b) applying hydrothermal processing to create biochar, syngas and bio-oil from the plant biomass used for phytoremediation; c) degrading the PFAS in the hydrochemical conversion process. The aim is to reduce the amount of PFAS in biosolids to a level that makes it safe to use as fertilizer while also creating other marketable goods that are low in PFAS. This study covers the literature to assess the potential techniques involved in this methodology, as well as determine the viability of the methodology by using a Swedish wastewater treatment plant as a case study.

Keywords: **PFAS, biosolids, phytoremediation, hydrothermal processing**

ET061

HIGH-POWER CHARGING SOLUTIONS FOR ELECTRIC TRANSPORT: RVIEW OF EXISTING TECHNOLOGIES AND APPROACHES

Mārtiņš Tisenkopfs, Aigars Laizāns

Latvia, Latvia University of Life Sciences and Technologies (LBTU)

Abstract. High-power charging infrastructure for electric transport is becoming one of the most significant challenges in the development of modern energy and transport systems. This issue is particularly relevant in sectors such as agriculture, public transport with electric buses, as well as airport and port infrastructure, where the development of new fast charging solutions is required. Although the deployment of high-power charging infrastructure is progressing relatively slowly, it is strategically important for reducing emissions and ensuring sustainable development. It is also closely linked to the objectives of the bioeconomy, as it promotes more efficient resource use, integration of renewable energy sources, and reduction of environmental impact. Electrification in agriculture is becoming an essential tool for ensuring compliance with the requirements of the European Green Deal, while also creating the conditions for a competitive, climate-neutral, and innovative bioeconomy. To enable rapid, high-power charging within a short time, significant demands are placed on power supply systems that were not originally designed to handle such high-intensity, short-duration loads. This leads to voltage fluctuations, grid instability, reduced power quality, and high costs associated with expanding connection capacity. This review examines the key challenges in implementing fast charging for electric transport: insufficient grid capacity to cover sudden high-power demand peaks, grid load imbalance and voltage drops, limited and costly options for grid capacity expansion, as well as charging speed limitations within the existing infrastructure. The review also highlights the most effective solutions, which are based on integrated technologies — the use of energy storage systems (ESS), smart control algorithms, and microgrid architectures.

Keywords: **Keywords, fast charging, electric transport, energy storage systems, microgrids, smart control, grid stability**

ET062

CIRCULAR BIOMASS OF MICROALGAE IN COLD CLIMATE

Erik Grönlund, Emiel Driessen, Susanne Tellström

Sweden, Mid Sweden University

Microalgae have been in focus for several decades in ecological engineering, however mostly at lower latitudes with warmer climate. Resilient societies need technology with high recycling possibilities, and what can be called a circular biomass of microalgae provides an interesting path for this. From a recycling point of view the nutrients in wastewater is of highest interest. Many wastewater treatment technologies use microalgae as an important part. Modern wastewater treatment often suffers from the problem of being a linear system, rather than a recycling system. The use of microalgae has been proposed as collection systems for the nutrients, with several potential advantages: 1) they treat the wastewater further from a pathogenic point of view, 2) they produce a sludge of interesting biochemical quality depending on the species present in the treatment ponds, what can be called a circular biomass, 3) they use the naturally occurring ecosystem services available at the wastewater treatment site in the form of sunlight, wind, and regional biodiversity of phytoplankton. The academic focus regarding microalgae use for wastewater treatment mostly has been on the “sunbelt”, between latitudes 35 North and South, respectively. However, a few investigations have been performed on northern and southern latitudes. This paper investigates how microalgae can play a role in ecological engineering solutions in colder climate conditions at higher latitudes and summarizes experiences from using microalgae for wastewater treatment at northern latitudes in Sweden and present suggestions for further research to make use of microalgae as circular biomass.

Keywords: **subarctic climates, phytoplankton, HRAP, ecological engineering, CirBio**

ET063

FOOD WASTE DERIVED POLYPHENOL-CLAY COMPOSITES FOR UV PROTECTION AND SKIN HEALTH

Aiga Salmina, Rūta Ozola-Davidāne

Latvia, Latvia University of Life Sciences and Technologies (LBTU)

The skin, as the largest organ of the human body, serves as a vital barrier against external environmental factors, with ultraviolet (UV) radiation being one of the most harmful. Although moderate UV exposure is necessary for vitamin D synthesis, long-term or excessive exposure leads to oxidative stress, inflammation, premature ageing, and skin cancer development. Both UVA and UVB rays trigger different but interconnected pathways of damage, including DNA alterations, activation of inflammatory responses, degradation of extracellular matrix components, and suppression of the immune system. Current sunscreen solutions remain problematic as chemical filters raise concerns about endocrine disruption, bioaccumulation, and environmental toxicity, while mineral filters are hindered by poor texture and limited formulation compatibility. Furthermore, within the European Union, only a few natural-origin UV filters are officially approved, underlining the urgent demand for new, safe, and sustainable alternatives. Polyphenols, abundant in natural sources such as tea and coffee, are known for their strong antioxidant, anti-inflammatory, and photoprotective properties, but their instability under light, oxygen, and pH variations restricts practical use. Clay minerals provide a promising solution, offering structural stability, high adsorption capacity, and inherent UV-protective properties. By integrating polyphenols from the food and beverage industry with natural clay minerals, it becomes possible to design multifunctional UV filters that are not only effective and safe for consumers but also environmentally responsible, aligning with circular economy principles. Acknowledgements: This research was supported by the long-term national research programme“Biomedical and Photonics Research Platform for Innovative Products” project “Multifunctional Polyphenol-Clay Composite for Natural UV Protection and Skin Health (POLYCLAY-UV)” (No. PIP_BioPhoT-2025/1-0065).

Keywords: **UV radiation, polyphenols, clay minerals, natural UV filters, circular economy**

ET064

USE OF ANAEROBIC FACULTATIVE MICROORGANISMS FOR SEWAGE SLUDGE MANAGEMENT

Irina Kliopova, Rimas Pranas Budrys

Lithuania, Kaunas University of Technology (KTU)

Odor emission generated during biodegradable waste (BDW) management remains a major problem. These odors arise from the decomposition of organic matter by microorganisms, releasing volatile compounds (e.g., ammonia (HN3), hydrogen sulfide (H2S), non-methane volatile organic compounds (NMVOC)). Traditional odor control methods require significant energy resources and financial investment, but do not eliminate the cause of the odor. In the proposed new biotechnology, a special mixture of anaerobic facultative microorganisms (AFM) is injected into the BDW flow. These AFM accelerate the decomposition process of organic waste, but during their metabolism, odorous compounds are not formed. Verification studies of the proposed biotechnology, determining the optimal dosage of the microbiological preparation, were carried out in various BDW (manure, sludge, food and green waste). The presentation will show the results of research proving the environmental and economic efficiency of the proposed technology, optimize sewage sludge management processes. The researches were carried out at 3 wastewater treatment plants. It was determined that injection of proper volume of AFM will allow reducing odorous compounds: - during BDW storage (upstream of digesters): H2S - up to 86%; NH3 – up to 97%; - during classic open sewage sludge or digested sludge and green waste composting: NH3 – from 26.8 up to 97%; odor emissions – by average 57.8%. The application of the proposed biotechnology will allow preventative reducing air pollution and odors during the treatment of sewage sludge and producing a more valuable product - soil improver, thereby contributing to the implementation of the principles of the circular economy. Laboratory tests have shown that the quality of the resulting fertilizer product improves: NPK values and humus content increase, and the growth of pathogenic microorganisms (e.g., E. coli, Enterococcus spp., Staphylococcus aureus) is suppressed.

Keywords: **Biodegradable waste management, anaerobic microorganisms, odor emission, biotechnology**

ET065

"THE IMPORTANCE AND APPLICATION OF GEOMAGNETIC MEASUREMENTS OF THE EARTH IN GEOPHYSICAL PROCESSES"

Toms Līdumnieks

Latvia, Latvia University of Life Sciences and Technologies

Abstract. The Earth's magnetic field is a critical component of our planetary system, generated primarily by the movement of molten iron in the outer core. The Earth's magnetic field is like a large magnet. The Sun experiences magnetic storms that are responsible for climate and various environmental problems. Measurements of this geomagnetic field are a fundamental tool in geophysics, providing invaluable insight into processes from the deep interior to the upper atmosphere. This summary highlights the importance and diverse applications of these measurements - geology, radio interference, etc. Geomagnetic data are crucial for understanding the dynamics of the Earth, including the geodynamic mechanism and processes at the core-mantle boundary. Geomagnetism plays a crucial role in mapping and direction finding, when we navigate with a simple magnetic compass in our daily lives. In addition, they are used to probe the electrical conductivity structure of the mantle and crust using magnetotellurics, revealing information about composition, temperature, and fluid content. Near-surface high-resolution magnetic surveys are indispensable for geological mapping, mineral and hydrocarbon exploration, and volcanic and seismic hazard assessment. Beyond the solid Earth, continuous geomagnetic monitoring is essential for tracking space weather events, where solar activity can cause currents that threaten modern technological infrastructure (GNSS). In general, geomagnetic measurements serve as a means of resolving various geophysical processes.

Keywords: **Earth magnetic field, Geomagnetic field, Geomagnetic measurements, Geomagnetic anomaly**

ET066

INFLUENCE OF QUERCUS ROBUR AND QUERCUS RUBRA TREE STANDS ON RICHNESS OF MICROBIOTA IN ORGANIC AND MINERAL SOIL LAYERS

Nijolė PETRAITYTĖ, Svajūnė Grubinskaitė, Vitas Marozas

Lithuania, Vytautas Magnus University (VMU)

The study was carried out in spring (May), summer (August) and autumn (November) of 2024 in the homogeneous plantations of native English oak (Quercus robur L.), and alien Northen red (Quercus rubra L.) monocultures. The age of the studied plantations was 60 years. They were dominated by anthropogenic Endocalcari–Epihypogleic Cambisols.The biochemical analysis of autumn litter was defined also. Biochemical analysis of litter showed that the concentration of water-soluble carbohydrate was twice higher and cellulose – about 20% higher in litter of Q. rubra, than of Q. robur. However, litter of Q. robur contained twice higher N, 30% higher lignin, 40% higher P, 35% higher K amounts. The other traits (Ca, Mg, Corg., ash) either pH (5.2-5.4) were quite similar. Tyrimo metai išsiskyrė The richness of microbiota was highest in summer and autumn and lower in spring samplings for both investigated tree species. There were much more bacteria in litter and soil of Q. robur than of Q. rubra. Especially significant differences of abundance of bacteria were found in summer and autumn litter samplings. However, the higher numbers of microscopic fungi were found in litter of Q. rubra spring and summer samplings. The higher diversity of fungal genera was found in litter and soil layers of Q. robur than of Q. rubra. The most frequent (≥ 10%) genera were Penicillium, Cladosporium, Trichoderma, Verticillium in litter of Q. robur and Penicillium, Cladosporium – in litter of Q. rubra. Penicillium and Trichoderma were most abundant genera in soil layers of both studied tree stands. These differences of microbial richness found could be determined not only by the biochemical composition of litter, but also by meteorological conditions.

Keywords: **bacteria, biochemical composition, diversity, genera, microscopic fungi**

ET067

GREEN TECHNOLOGIES AND SUSTAINABLE DEVELOPMENT OF AGRICULTURE IN UKRAINE

Dmytro Solomonko

Ukraine, Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv

Green technologies plays a vital role of agriculture and rural areas development in European Union. Ukraine make a huge reform during wartime for agricultural transformation and food security providing in the path to foster EU integrational processes. During 2022-2025 a lot of ecological damages influence on farming business in Ukraine as the result of poorly controlled processes of confrontation. New green technologies that elaborates in Ukrainian universities create a prerequisite during mass implementation by farms. European farming policy much attention is paid to supporting farmers in the direction of green development policies and production processes transformation.The lack of significant financial resources hinders farmers from adopting technologies that ensure balanced development of agriculture in Ukraine. The policy of supporting the development of agriculture is significantly focused on the introduction of technologies that ensure UN Sustainable Development Goals.Limitations in the availability of state support for farmers also significantly hinder the implementation of technologies that ensure green transition in Ukraine. The organizational and economic mechanism for supporting farms in the implementation of innovative technologies is systematically, albeit with a certain slowdown, adapting to the best EU practices. The introduction of technologies is a more important component in increasing the competitiveness of Ukrainian farms on the European market than for EU farmers.

Keywords: **green technologies, farming, rural development, sustainable development**

ET069

EFFECT OF ORGANIC CULTIVATION OF WINTER WHEAT ON AGROCHEMICAL AND MICROBIOLOGICAL SOIL PARAMETERS IN THE FOREST-STEPPE ZONE OF UKRAINE

Kuts Oleksandr, Vladislav Bolokhovskyi, Ivan Semenenko, Yana Svishchova

Ukraine, State Biotechnological University, Ukraine, LLC "TD BTU-Center", Ukraine, 1. Engineering and Technological Institute "Biotekhnika" of NAAS

The study evaluates the influence of microbial preparations on the agrochemical and microbiological characteristics of typical chernozem under organic cultivation of winter wheat in the Forest-Steppe zone of Ukraine. Field experiments were conducted during 2021–2025 using two systems: conventional technology with mineral fertilizers and chemical protection products, and an organic technology based on microbial consortia. The application of microbial preparations, including MikoHelp, AzotoHelp, Organic Balance Monophosphate, and HelpRost Cereals, enhanced nitrogen fixation, phosphorus solubilization, and cellulose degradation in the soil. As a result, the content of easily hydrolyzed nitrogen increased by 21.7%, and available phosphorus by 18.2–54.5% during the vegetation period compared with the mineral-fertilized control. The population of cellulose-degrading and oligonitrophilic microorganisms increased, indicating enhanced mineralization of crop residues and improved soil biological activity. The potassium content in the arable soil layer remained stable, showing microbial mobilization of poorly soluble compounds comparable to 30 kg K ha^{-1}. The technology based on microbial preparations also led to a balanced nutrient transformation and preservation of soil biogenicity. These results demonstrate that integrating microbial preparations into organic farming systems contributes to restoring soil fertility, optimizing nutrient cycling, and ensuring environmentally sustainable production of winter wheat in temperate climates.

Keywords: **organic cultivation, winter wheat, microbial preparations, soil fertility, agrochemical properties, microbiological activity**

ET070

ANAMMOX BACTERIA RECOVERY FROM HIGH NITRITE CONCENTRATIONS BY NITRIC OXIDE FOR INHIBITION-FREE NITROGEN REMOVAL IN BIOFILM WATER TREATMENT

Ivar Zekker, Daliana Patricia Gonzalez Solano, Rūta Ozola-Davidāne, Juris Burlakovs, Andrey E. Krauklis, Zane Vincevica-Gaile, Jovita Pilecka-Uļčugačeva, Inga Grīnfelde

Estonia, University of Tartu, Costa Rica, University of Costa Rica, Latvia, Latvia University of Life Sciences and Technologies (LBTU), Latvia, Geo IT Ltd, Latvia, University of Latvia (LU)

Treating nitrogen-rich wastewater in conventional wastewater treatment plants via the nitrification-denitrification process is energy-intensive and costly, primarily due to high aeration demands and the requirement for external organic carbon sources. In contrast, partial nitrification combined with the anaerobic ammonium oxidation (anammox) process offers a more sustainable alternative by significantly reducing both- aeration needs and reliance on organic carbon. However, nitrite inhibition challenge in this system could be eliminated by the usage of nitric oxide (NO), a highly reactive and toxic intermediate to many bacteria other than anammox bacteria, generated by nitrogen-converting microbes, also anammox bacteria. Even at micromolar levels, NO can inhibit key microbial groups like nitrifiers and denitrifiers and contribute to atmospheric pollution. Paradoxically, NO reuse also plays a crucial stimulatory role in the anammox process. While anammox bacteria are sensitive to high nitrite concentrations, their activity can be enhanced by trace amounts of NO, helping to counteract nitrite inhibition. This study aimed to investigate how the controlled addition of specific quantities of the anammox intermediate NO effects deammonifying biofilm performance under elevated nitrite conditions (60 mg NO_2^--N L^{-1}). Quantitative PCR analysis revealed a significant increase in Planctomycetales clone P4 sequences—closely related (98–99% similarity) to Candidatus Brocadia fulgida—which abundance rose to 1×10^6 anammox gene copies per gram of total suspended solids (TSS) by day 650 of reactor operation, indicating successful enrichment and sustained activity of anammox bacteria under these conditions. These findings provide a practical strategy for stabilizing anammox-based wastewater treatment under fluctuating nitrite levels.

Keywords: **Biogas tank rejected water, deammonification, fluctuating aeration, inhibition by nitrite**

ET071

ACCURACY AND RELIABILITY OF SUPERVISED CLASSIFICATION METHODS FOR ESTIMATING THE COVER OF LAKES' REED BEDS BY SENTINEL-2 IMAGERY

Grigorijs Goldbergs

Latvia, Institute of Electronics and Computer Sciences

Reed (Phragmites australis) is one of the dominant plant species in European land-water environments. The use of satellite imagery is an efficient part of reed beds mapping and change detection monitoring. This study aims to perform an accuracy assessment of four supervised classification methods: the maximum likelihood (ML), machine learning classifiers such as support vector machines (SVM) and random forest (RF), and the deep learning artificial neural network (ANN) algorithm for separating clear water from coastline and wetland vegetation, primary reed beds. The main goal was to assess the efficiency and stability of these classifiers in the summer period using Sentinel-2 imagery from 2015 to 2024 for the Riga city water areas. The study used only one training dataset from a single date in 2018 for all S2 imagery to gain insights into practical steps for avoiding the need to collect training data for every new image. The study results demonstrated that the ANN classifier achieved marginally better overall results than ML and RF, with an advantage in classifying water bodies and reed areas. The SVM classifier showed the worst results (class mismatch), as a training set associated with each corresponding imagery date is needed to obtain reliable results. Overall, the S2 imagery time series classification can achieve satisfactory results using ML, RF, and ANN classifiers based on a single training set, though there are some limitations. S2 imagery must be used from late May to the end of August with leaf-on vegetation, covering a range of 1-1.5 months from the training set date to minimise changes in solar radiation and sun elevation angles. However, this does not affect the accuracy of clear water separation from other classes. Thus, the study offers a binary mask as an optimal solution for separating the clear water from non-water classes (mostly reed beds).

Keywords: **Reed beds, Sentinel, 2, Land use and land cover, Supervised classification**

ET072

LONG-TERM SOCIO-ECONOMIC IMPACTS OF SCENARIOS OF RESTRICTIONS ON THE MANAGEMENT OF COMMERCIAL PINE FORESTS

Dagnija Lazdiņa

Latvia, Latvian State Forest Research Institute "Silava" (LVMI Silava)

To ensure the practical and political relevance of long-term forest management restrictions, stakeholders were engaged to define the most plausible scenarios for modelling. The model was developed by integrating the effects of forest management on adaptation, growth, and tree vitality identified within the Forest4LV project into the existing yield modelling framework. A holistic assessment of forest management changes was achieved by supplementing the model with adjusted allometric calculations of key ecosystem services and biodiversity indicators as well. To enhance the model's accuracy and policy relevance in assessing the climate change mitigation potential of the forest sector, substitution effects of wood-based products and technologies replacing fossil resources were parameterized. Scenario calculations included business-as-usual conditions, expansion of strictly protected forests or forests without economic activity (from 8.2% to 10%), and an increase in protected forests or those managed under non-clearcut forestry (from 6.4% to 20%), combined with more intensive management of so-called production forests. Intensified management practices encompassed forest fertilization, tending, thinning, renovation of existing drainage systems, replacement of nonproductive forest stands and establishment of new forest. Preliminary results indicate that changes in forest resources are observable only in the short term; however, enhanced management of production forests may compensate for the resource losses resulting from increased nature protection areas.

Keywords: **forest policy, climate mitigation modelling, sustainable resource management, scenario analysis, green economy, land, use plannin**

ET073

CHALLENGES IN THE APPLICATION OF ACOUSTIC MEASUREMENT TECHNOLOGIES IN RIVERBED ENGINEERING INVESTIGATIONS

Edita Abalikštienė

Lietuvos Inzinerijos Kolegija Higher Education Institution, Lithuania

The aim of this study is to identify and evaluate the challenges associated with the application of acoustic measurement technologies in riverbed engineering investigations, with a focus on assessing riverbed morphology and the effects of dredging operations. Field measurements were conducted using single-beam echo sounders and multibeam sonar systems along systematically distributed cross-sectional profiles, providing high-resolution data on riverbed topography. The number of measurement points was adjusted according to river channel width and bed morphology: for narrow, uniform channels (10–100 m wide) with the navigable lane near the center, 10–20 points were used; for medium-width channels (100–300 m) with relatively uniform beds, 20–30 points were applied; and for wider channels (300–1000 m), 40–50 points were recorded to ensure adequate representation of bed topography. The study discusses the strengths and limitations of different bathymetric methods: single-beam echo sounders for localized surveys, multibeam sonars for precise large-scale mapping, side-scan sonars for visual representation, and airborne LiDAR or photogrammetry for surveys from above, which are limited by water clarity. Analysis of the collected data revealed significant morphological changes and areas that could potentially affect navigation safety. Purposeful selection or combination of measurement techniques is essential to optimize both data accuracy and spatial coverage, providing practical guidance for improving acoustic survey strategies in sustainable river management and navigation safety.

Keywords: **Acoustic measurement technologies, Riverbed engineering, Bathymetric surveys**

ET074

DESIGN OF A STRESS-CORROSION SETUP FOR STUDYING THE MECHANOCHEMICAL DEGRADATION OF GLASS FIBERS IN HYDROUS ENVIRONMENTS

Andrejs Krauklis, Juris Burlakovs, Hani Amir Aouissi, Inga Grīnfelde, Ivar Zekker

Latvia, Latvia University of Life Sciences and Technologies (LBTU), Poland, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Algeria,, Estonia, University of Tartu

The mechanochemical degradation of glass fibers under simultaneous stress and water exposure is a critical durability issue for fiber-reinforced polymer composites used in marine, offshore, and humid environments. This work presents the design and development of a stress-corrosion setup enabling quantitative measurement of glass fiber dissolution under mechanical load in a controlled hydrous environment. The setup integrates precise mechanical control, temperature regulation, and chemical analysis via High-Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS), allowing real-time monitoring of ion release during stress-assisted corrosion. A key design challenge was eliminating background contamination from the apparatus, as leaching of silicon or metallic ions could distort dissolution kinetics. To address this, several polymeric coating materials for the pushing rod were screened for ion release using HR-ICP-MS. Among the tested candidates - four polyurethanes, polyvinylchloride (PVC), poly(methyl methacrylate) (PMMA), and silicone - PVC and PMMA showed negligible leaching and were identified as optimal coating materials, while silicone exhibited extensive Si release and was excluded. When combined with the Dissolving Cylinder Zero-Order Kinetic (DCZOK) model, the setup provides a mechanistic framework to link applied stress with the activation energy and rate constants of mechanochemical stress corrosion of glass fibers in hydrous environments, providing insights critical for lifetime prediction of composite structures. Preliminary experiments demonstrate that applied stress accelerates corrosion by reducing the activation energy of dissolution, consistent with stress-assisted hydrolysis of Si–O bonds.

Keywords: **stress corrosion, glass fibers, mechanochemistry, environmental degradation, dissolution kinetics, polymer coatings, HR, ICP, MS**

Acknowledgments: A. Krauklis acknowledges F-TEN4 support.

ET075

CURRENT STATUS AND FUTURE PERSPECTIVES FOR PEATLAND EXTRACTION SITE RECULTIVATION IN LATVIA

Normunds Stivriņš

Latvia, University of Latvia

Latvia's peatlands have been widely altered by drainage and land-use change, with peat extraction representing one of several drivers. Approximately 25,000 hectares are currently under active industrial extraction, while over 35,000 hectares of former extraction fields are abandoned or in various stages of recultivation. In recent years, Latvia has intensified work on post-extraction recovery through rewetting, vegetation re-establishment, and alternative land-use pathways. National projects and pilot studies indicate that restoring near-natural hydrological regimes could reduce CO_2 emissions and support the return of characteristic mire biodiversity. Recultivation approaches include paludiculture, sustainable biomass production, wind power plant and agrovoltaic integration on suitable post-extraction surfaces. This presentation summarises the current status of former extraction areas, recent monitoring results, and methodological advances in hydrological modelling and greenhouse gass emission assessment. Future perspectives are framed by Latvia's climate targets, evolving European Union restoration policy, and the transition toward sustainable, multifunctional peatland management that balances ecological outcomes with practical land-use options.

Keywords: **stress corrosion, glass fibers, mechanochemistry, environmental degradation, dissolution kinetics, polymer coatings, HR, ICP, MS**

ET076

APPLICATIONS AND ENVIRONMENTAL SUSTAINABILITY OF PLANT-BASED NATURAL FIBER COMPOSITES

Subrata Chandra Das, Andrejs Krauklis

Norway, Department of Manufacturing and Civil Engineering, Norwegian University of Science and Technology (NTNU). Latvia, Faculty of Forest and Environmental Sciences, Institute of Civil Engineering and Woodworking, MEI Core Group, Latvia University of Life Sciences and Technologies.

Plant-based natural fiber composites have garnered significant attention from both industry and academia due to their unique advantages over synthetic fiber composites (e.g., GFRPs or CFRPs). These advantages include low density, favourable specific stiffness, ease of processing, non-toxicity, biodegradability, and good insulation performance compared to synthetic fibers, such as glass fibers. Commonly used plant fibers include flax, hemp, sisal, jute, kenaf, banana, bamboo, coir, date palm, oil palm, abaca, etc. Their low cost and reduced carbon footprint further enhance their appeal as sustainable alternatives. These composites are widely adopted in automotive components and are increasingly being explored for applications in sports equipment, musical instruments, household goods, construction, maritime, aviation, electronics, wind energy, and even space technologies. Despite their benefits, natural fiber composites face challenges related to durability, primarily due to the moisture sensitivity of plant-based fibers and exposure to environmental stressors during service life. From a sustainability perspective, natural fiber composites perform best when combined with bio-based or recyclable polymer matrices, supporting cradle-to-grave lifecycle approaches. However, environmental concerns remain, particularly related to agricultural practices used in fiber cultivation. This study highlights the diverse applications of plant-based natural fiber composites and critically examines their environmental performance in the context of sustainable material development.

Keywords: **plant-based natural fibers; natural fiber composites; sustainable composites; applications of composites; environmental performance; eco-friendly composites.**

Acknowledgments. A. Krauklis acknowledges F-TEN4 support.

ET0077

SUSTAINABLE INTEGRATION OF AQUAPONICS WITH RECYCLED GREYWATER SYSTEMS

Härmo Hiiemäe, Daaniel Maanas, Priit Tamm, Merrit Shanskiy, Rihard Reissaar, Merilin Noormets, Morten Poolakese, Mait Kriipsalu

Estonian University of Life Sciences, Tartu, Estonia

Aquaponics defines as a farming method utilizing symbiosis between fish and vegetables, designed to reduce the usage of freshwater and the wasting of nutrients. This approach facilitates circular food production in urban areas, allowing for the all year-round cultivation of both vegetables and fish. This INTERREG TransFarm (Transborder Cooperation for Circular Soilless Farming Systems) project demonstrates a closed-loop system, achieving minimal freshwater usage by substituting it with recycled greywater within the limits specified by EU commission (EU) 2020/741 for water reuse. Aquaponics and recycled aquaculture system was installed at Estonian University of Life Sciences. The main water treatment installation was commercially available Hydraloop H600. Greywater was harvested from shower room of University's sports hall. Hydraloop's technology uses six purification methods – sedimentation, flotation, dissolved air flotation, foam fractionation, an aerobic microbiological treatment in Moving Bed Biofilm Reactor, and UV disinfection. It collects and treats 360 l of greywater with one cycle. There are max 3 cycles per day. Equipment stores 240 liters of treated reuse water, which was available for aquaponics. The main species cultivated between August 2024 and May 2025 was the African sharptooth catfish (*Clarias gariepinus*), designed 24 kg/m^3. Black soldier fly (BSF) larvae was tested either live or dried in aquaponic system to enhance fish wellbeing by enabling them to actively hunt and reduce cannibalism. For plants, the aquaponics system utilized 12 trays covering 6 m². Key crops included tomato, okra, oregano, chives (Alliums), basil, peppermint, sorrel (Rumex), and pak-choi. Full-spectrum LED grow lights were used, mimicking sunlight, with a photoperiod duration adjustable between 12 and 14 h. The project confirmed that greywater could be successfully treated and purified to be suitable for aquaponics, meeting the regulation of (EU) 2020/741. For example, the effluent BOD_7 was 6.2 mgO2/l at its highest. Pathogenic indicators like E. Coli and Enterococci reduced from 17,220 to 0 counts/100 ml and from 500 to 0 counts/100 ml, respectively. The African catfish load was significantly higher than designed - max 119 kg/m^3. The system carried 81 catfish, reaching 90 kg from average 10 g up to 1115 g average of individual biomass within 230 days and a Feed Conversion Ratio (FCR) of 1.2. The high fish load caused issues, including substantial sediment and frequent blockages. Oxygen levels in the fish tank were often alarmingly low (0.2 to 3.0 mg/l), although African catfish were highly tolerant to these conditions. Catfish, being more nocturnal creatures, did not actively feed when there was light present, but in darker

conditions, in shade feed frenzy activated and larvae disappeared within minutes. That shows that the fish are actively looking to feed in the dark and the BSF larvae are giving off enough biological markers to be spotted as pray. The aquaponics system showed excellent growth for basil and peppermint, and good growth for Chives a. Okra produced a consistent number of pods and showed moderate to vigorous vegetative growth. Tomato plants produced high biomass but only a few, mostly unripe, fruits. However, oregano did not survive due to poor establishment and stunted growth, displaying signs of nutrient deficiency early on. Significant formation of sediment was noticed in the bottom of the plant trays. The results confirm that closed-loop aquaponics using recycled greywater is technologically viable. However, system stability requires careful management of the biological load. It recommends that the total fish mass have to be reduced to balance with the needs of plants and to minimize lack of oxygen in fish tanks, and minimise blockages in pipelines and trays.

Keywords: **Aquaponics; Greywater reuse; Closed-loop farming system; Clarias gariepinus; Black soldier fly larvae; Water reuse regulation (EU) 2020/741; Urban circular food production; Sustainable aquaculture; Hydraloop H600; Plant–fish symbiosis.**

ET0078

LESSONS LEARNED FROM RECYCLED WATER PILOT: GREYWATER VERSUS RAINWATER.

Priit Tamm, Harald Kriisa, Morten Poolakese, Mait Kriipsalu

Estonian University of Life Sciences, Tartu, Estonia

Two similar recycled water systems were installed at Estonian University of Life Sciences, both indoors, feeding similar aquaponics system. Greywater was harvested from shower room of University's sports hall, and rainwater was received from flat roof, approx. 300 m^2. The greywater treatment installation was commercial Hydraloop H600. Hydraloop's technology uses six purification methods – sedimentation, flotation, dissolved air flotation, foam fractionation, an aerobic microbiological treatment in Moving Bed Biofilm Reactor, and UV disinfection. It collects and treats 360 l of greywater with one cycle. There are maximum 3 cycles a day. Equipment stores 240 l of treated reuse water, which was available for aquaponics.

The rainwater treatment installation was custom-made system, using filtration, ultrafiltration and disinfection by choice of UV, ozone or chlorine. Equipment was set to purify and store 800 l/d, and was continuously recirculating through UV. Backflow from aquaponics was recycled between fish and plant section, and not purified in water treatment system any more. Lessons learned from ten-month long stable run were as following. In general, both installations provided the customer (aquaponics) with recycled water of sufficient flow and adequate quality. No adverse effect for aquaponics production was noticed from neither of the systems. Both water sources, however, were unstable and unsecure if steady flow was needed. This can be solved by buffering in external water tanks.

Rainwater storage is more realistic than storage of raw greywater. In both cases, there must be an alternative water supply, which switches on automatically. Commercial equipment tends to contain better engineering, but is more difficult to repair, particularly under warranty conditions. This requires assistance from professional service.

Custom-made equipment is easier to repair. We recommend online monitoring system with set alarms. Certain alarms already exist in commercial units, but even then, we recommend to custom-adjust it to meet site-specific needs. Biological treatment requires 21 d to become operational, whereas filter-based systems react much faster. We prefer strict maintenance routine rather than problem-based routines.The main concern was microbiology. In our case, legionella was occasionally noticed. This can be avoided by increasing the purification cycles of recycled water through a UV device. Chlorine and ozone were not appropriate in our hydroponics system. Aquaponics experiment was successful, and did not differ from systems running on tap water.

Unlike in case of municipal water supply systems, however, pumping hardware, sensors, automatics and maintenance are on shoulders of a customer – the owner of recycled water system. This requires skills, tools, spare parts and creativity.

Keywords: **Recycled water systems; Greywater treatment; Rainwater harvesting; Aquaponics; Hydraloop H600; UV disinfection; Water reuse; System maintenance; Legionella control; Sustainable urban farming.**

ET079

GROUNDWATER TABLE DEPTH MONITORING DATASET (2023-2025) FROM AN EXTRACTED KAIGU PEATLAND SECTION IN CENTRAL LATVIA

Normunds Stivrins, Janis Bikse, Sabina Alta, Inga Grinfelde

Latvia, Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technologies, Latvia, Department of Geology, Faculty of Science and Technology, University of Latvia, Ltd. Laflora, Jelgava, Lithuania, Lietuvos Inžinerijos Kolegija | Higher Education Institution.

Extracted peatlands experience strong hydrological fluctuations due to drainage, vegetation succession, and climatic variability, yet long-term, high-frequency groundwater data remain scarce in Northern Europe. Our dataset presents two years (June 2023 – May 2025) of 30-minute groundwater table depth (WTD) measurements from six wells in-stalled across contrasting Greenhouse Gass Emission Site Types (GEST 5, 6, 15, 20) in the Kaigu peatlands, central Latvia. Each well was equipped with an automatic pressure transducer (TD-Diver, van Essen Instruments) recording absolute pressure (m H2O) at 30-minute intervals. The dataset also includes metadata on coordinates, installation elevation, well construction, and manual control measurements. All values are unpro-cessed, i.e., they represent original logger outputs without atmospheric or elevation correction, enabling users to apply their own calibration or referencing methods. This is the first openly available high-frequency extracted peatland groundwater pressure da-taset from the Baltic region and provides a foundation for hydrological modelling and rewetting designs.

Keywords: **Extracted peatlands; Groundwater table depth; High-frequency monitoring; Pressure transducers; Hydrological fluctuations; Greenhouse Gas Emission Site Types (GEST); Kaigu peatland; Baltic region; Rewetting design; Hydrological modelling.**

ET080

CURRENT STATUS AND FUTURE PERSPECTIVES FOR PEATLAND EXTRACTION SITE RECULTIVATION IN LATVIA

Stivrins, N., Ozola, I., Andriksons, M., Grinfelde, I.

Latvia, Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technologies, Latvia, Lake and Peatland Research Centre, Latvia, Department of Geology, University of Latvia, Lithuania, Lietuvos Inžinerijos Kolegija Higher Education Institution,

Peatlands cover approximately 10% (640 000 ha) of Latvia's territory, of which ~51 000 ha are officially classified as degraded. Using combined published and unpublished project data together with literature sources and updated licence records, two restoration scenarios were modelled: (1) a baseline, licence-expiry scenario, where extraction continues until existing permits end, and (2) an accelerated "immediate-stop-peat-mining" scenario, achieving full restoration by 2050. Our results show that reaching full recultivation would require restoring ~1550 ha yr-1 under the baseline and ~2000 ha yr-1 under the accelerated scenario. Recent EU-funded and private projects demonstrate rewetting, paludiculture, and renewable-energy integration, but only a few sites are officially recognised as fully recultivated. Given that ecological recovery may take decades, administrative completion alone does not ensure peatland functionality. A phases, licence-expiry based restoration strategy, focusing on degraded and self-regenerating areas, appears on of he most feasible and realistic approaches. This pathway aligns with the EU Nature Restoration Law and LULUCF Regulation, balancing climate goals with Latvia's bioeconomic interests and the sustainable use of peat within a circular bioeconomy.

Keywords: **Peatland restoration; Degraded peatlands; Rewetting; Paludiculture; Licence-expiry scenario; Climate mitigation; LULUCF Regulation; EU Nature Restoration Law; Circular bioeconomy; Latvia.**

ET081

SUSTAINABLE DEVELOPMENT OF WIND ENERGY IN HYDROLOGICALLY SENSITIVE LANDSCAPES: THE "DALBE" CASE STUDY

Inga Grinfelde

Latvia Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technologies, Lithuania, Lietuvos Inžinerijos Kolegija | Higher Education Institution.

Wind farm construction in forested areas requires detailed hydrological evaluation because forests regulate water balance differently from open landscapes. In Latvia, where annual precipitation exceeds evapotranspiration and nearly half of forest lands are artificially drained, infrastructure development can cause local flooding, groundwater fluctuations, and erosion if unmanaged. This study assessed hydrological impacts for the "Dalbe" wind park located in the Zemgale Lowland, Latvia. Five groundwater monitoring wells were installed and equipped with pressure loggers recording at 30-minute intervals. High-resolution digital elevation data and the conceptual hydrological model METQ were used to simulate surface runoff and groundwater responses under alternative construction scenarios. Results show that groundwater level changes beneath turbine foundations reach up to 1.9 m but diminish to < 0.01 m within a 25–50 m radius, indicating strictly local effects. Predicted surface runoff increases were minor (≤ 0.05 $m^3 s^{-1}$), remaining well below existing drainage capacity. With proposed mitigation—sedimentation–filtration systems, slope stabilization, controlled timing of earthworks, and post-construction monitoring—no significant hydrological impact on Natura 2000 habitats is expected. The "Dalbe" case demonstrates that wind energy can be developed sustainably in hydrologically sensitive forest landscapes when supported by rigorous modelling, field monitoring, and adaptive management.

Keywords: **Wind farm; Hydrological assessment; Forest drainage; METQ model; Groundwater level; Surface runoff; Sustainable construction; Natura 2000; Zemgale Lowland; Latvia.**

ET082

WASTE TRANSFORMATION INTO SUSTAINABLE BUILDING MATERIALS: OPPORTUNITIES AND RISKS

Kristaps Siltumens, Jovita Pilecka-Uļčugačeva, Inga Grinfelde

Faculty of Forest and Environmental Sciences, Latvia University of Life Sciences and Technologies, Jelgava, Latvia

The increasing depletion of natural resources and the growing environmental concerns associated with waste disposal have intensified the search for sustainable alternatives in the construction industry. This literature review examines the transformation of various waste streams into building materials, highlighting their potential for resource efficiency, environmental benefits, and economic feasibility. The primary waste sources considered include industrial by-products, agricultural residues, municipal solid waste, construction and demolition debris, and electronic waste. Key transformation techniques such as mechanical processing, chemical activation, and thermal treatment are explored in terms of their effectiveness in converting waste into high-performance building materials. Applications in concrete and cementitious composites, bricks and blocks, insulation materials, road pavements, and composite panels are reviewed, with a focus on material properties, structural performance, and durability. Environmental implications of using waste-derived materials—including reductions in carbon footprint, waste diversion from landfills, and improvements in circular economy practices—are assessed through life cycle analysis. Economic considerations, regulatory frameworks, and challenges to standardization are discussed to evaluate large-scale applicability. The review concludes that waste valorization presents a viable pathway toward sustainable construction, though future research and supportive policy development are essential to enhance the adoption of waste-derived materials in mainstream building practices.

Keywords: **Waste valorization; Sustainable building materials; Construction waste recycling; Circular economy; Geopolymer concrete; Industrial by-products; Municipal solid waste; Green construction; Material transformation; Environmental sustainability.**

ET083

EXPERIMENTAL DATASET OF GREENHOUSE GAS EMISSIONS FROM LABORATORY BIOCOVER

Kristaps Siltumens, Inga Grinfelde, Juris Burlakovs

Latvia University of Life Sciences and Technologies, Latvia, Riga Technical University, Latvia

The dataset presented in this paper comprises three distinct data series collected during a controlled laboratory experiment aimed at quantifying greenhouse gas (GHG) emissions—methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O)—from different biocover compositions. The experiment was conducted in three consecutive phases starting in June, August, and October 2022. Each phase tested specific material combinations of fine-fraction waste, clay soil, compost, shredded paper, algae, gravel, ash, and chernozem, designed to evaluate their efficiency in mitigating GHG emissions. Gas flux measurements were taken weekly using a Cavity Ring-Down Spectroscopy (CRDS) analyzer (Picarro G2508) after a three-week stabilization period, with 321 total measurements recorded. The dataset includes raw, unprocessed outputs (in nmol m^{-2} s^{-1} for CH_4 and N_2O, and µmol m^{-2} s^{-1} for CO_2) along with metadata describing the sampling structure, sensor identification, and environmental conditions. Calibration and moisture–temperature control ensured data precision and reproducibility. The dataset offers high potential for reuse, including model calibration for landfill GHG emissions, validation of gas flow methodologies, meta-analyses of biocover performance, and development of machine learning algorithms for predictive emission modeling. This openly accessible dataset is the first of its kind in Latvia and contributes to the broader understanding of landfill emission reduction through biocover optimization, supporting circular economy and climate mitigation efforts.

Keywords: **Air pollution; Waste disposal; Methane oxidation; Greenhouse gas mitigation; Biocover technology; Cavity Ring-Down Spectroscopy (CRDS); Landfill gas emissions; Environmental monitoring; Data reuse; Circular economy.**

ET084

INTEGRATING BIOINDICATION AND SNOW CONTAMINATION ANALYSIS FOR LONG-TERM ASSESSMENT OF URBAN AIR QUALITY: A SEVEN-YEAR STUDY OF HEAVY METAL POLLUTION DYNAMICS IN JELGAVA, LATVIA

Inga Grinfelde, Inga Straupe, Kristaps Siltumens, Oskars Purmalis, Maris Bertins, Jovita Pilecka-Uļčugačeva

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Jelgava, Latvia University of Latvia, Faculty of Geography and Earth Sciences, Riga, Latvia

Urban air quality is a growing concern globally, particularly in cities where over half of the world's population resides, with urbanization rates expected to rise further. In Latvia, approximately 70% of the population lives in urban areas, where air pollution poses significant health and environmental challenges. This study investigates the dynamics of heavy metal pollution in Jelgava, Latvia, through the development of an innovative methodology that integrates bioindication techniques with snow contamination analysis. For the first time in Europe, this research provides a continuous seven-year dataset (2018–2024) on the accumulation of heavy metals in urban snow, offering a high spatial resolution of 1 km² across the city. Key findings indicate significant spatial variability in concentrations of heavy metals such as zinc (Zn 0.007–1002.1 µg/L), copper (Cu 0–829.50 µg/L), nickel (Ni 0.0005–40.40 µg/L), and lead (Pb 0.7–62.97 µg/L). Statistical analyses, including Kruskal–Wallis tests, identify transport corridors as critical contributors to air pollution, with statistically significant variations ($p < 0.0001$) observed across distance groups. The results underscore the complexity of urban air pollution processes and highlight the need for comprehensive monitoring frameworks that integrate long-term and short-term data, advanced spatial analyses, and cross-disciplinary approaches. The findings are pivotal for identifying pollution sources, assessing spatial risks, and guiding the development of urban planning and policy frameworks for sustainable city management. This research contributes to the global discourse on urban air quality, offering a replicable model for assessing and mitigating air pollution in complex urban environments.

Keywords: Urban air quality; Heavy metals; Bioindication; Snow contamination; Jelgava City; Long-term monitoring; Spatial variability; Sustainable urban planning.

ET085

ASSESSING LEAD CONTAMINATION IN SNOWMELT: SPATIAL DISTRIBUTION AND ENVIRONMENTAL RISKS IN JELGAVA

Jovita Pilecka-Uļčugačeva, Karlina Hirsfelde, Paula Miezaka, Maris Bertins, Inga Grinfelde

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Jelgava, Latvia, University of Latvia, Faculty of Geography and Earth Sciences, Riga, Latvia

Heavy metal pollution, particularly lead contamination, poses significant environmental and public health risks in urban areas. This study investigates the spatial distribution of lead in snowmelt within Jelgava, Latvia, to identify pollution sources and assess potential environmental impacts. From 2020 to 2024, snow samples were collected from diverse urban locations, including highways, railway-adjacent zones, industrial districts, and residential areas. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis revealed the highest lead concentrations near highways (16.33 µg/L) and railway infrastructure (6.71 µg/L), followed by industrial zones (3.77 µg/L) and residential areas (0.89 µg/L). These findings suggest that vehicular emissions, industrial activities, and domestic heating are the main contributors to lead accumulation in urban snow. Seasonal snowmelt acts as a major carrier of pollutants into stormwater systems, thereby increasing the risk of contamination in aquatic environments. The highest contamination levels were observed in areas of high traffic intensity, emphasizing the link between transportation emissions and atmospheric deposition. The study underscores the need for continuous environmental monitoring and the implementation of effective pollution mitigation strategies to safeguard urban water quality and public health. The methodology demonstrated here highlights the suitability of snow analysis as a reliable short-term bioindicator for identifying localized sources of heavy metal contamination in urban ecosystems.

Keywords: **Lead; Heavy metals; Urban environment; ICP-MS; Atmospheric deposition; Snowmelt; Pollution mitigation; Jelgava City.**

ET086

EVOLUTION OF WATER LEVELS IN THE RIVER LIELUPE: A PERSPECTIVE FOR JELGAVA CITY

Anda Bakute, Jovita Pilecka-Uļčugačeva, Inga Grinfelde

Institute of Landscape Architecture and Environmental Engineering, Latvia University of Life Sciences and Technologies, Jelgava, Latvia

The River Lielupe is a critical hydrological and ecological resource for Jelgava City, influencing agricultural productivity, urban development, biodiversity, and flood risk management. However, long-term fluctuations in water levels present increasing challenges, including heightened flood risks during wet periods and more severe low-flow conditions during droughts. This study provides a comprehensive analysis of multi-decadal daily water level data recorded at the Jelgava gauge station, employing statistical approaches to identify key temporal patterns and hydrological shifts. Results reveal significant increases in both mean and minimum water levels, accompanied by a decline in maximum levels, indicating evolving hydrological dynamics. These changes are attributed to altered precipitation regimes, intensified land use, upstream water regulation, and climate variability. The observed trends emphasize the importance of adaptive water resource management strategies designed to enhance basin resilience and maintain ecosystem stability. Recommended actions include improved flood protection infrastructure, sustainable water-use planning, and ecosystem-based management to ensure long-term hydrological balance. This research highlights the necessity of integrating climate adaptation, urban planning, and river regulation measures to sustain the ecological and socio-economic functions of the Lielupe River Basin in the face of ongoing environmental change.

Keywords: **Hydrology; River Lielupe; Water levels; Climate variability; Flood risk; Adaptive management; Jelgava City.**

ET087

CALIBRATION AND VALIDATION OF A CONCEPTUAL HYDROLOGICAL MODEL IN SWAMPY RIVER BASINS OF LATVIA

Anda Bakute, Normunds Stivrins, Inga Grinfelde, Jovita Pilecka-Uļčugačeva

Institute of Landscape Architecture and Environmental Engineering, Latvia University of Life Sciences and Technologies, Jelgava, Latvia, Department of Geography, Faculty of Science and Technology, University of Latvia, Riga, Latvia, Department of Geology, Tallinn University of Technology, Tallinn, Estonia

This study evaluates the performance of the conceptual rainfall–runoff model METQ2007BDOPT through detailed calibration and validation across five Latvian river basins with contrasting topographical and climatic characteristics, including swamp-dominated systems. Using long-term daily discharge data (1956–2006), the model's accuracy and stability were assessed under variable hydrological conditions. Results demonstrated satisfactory to good agreement between simulated and observed flows, with correlation coefficients (r) ranging from 0.77 to 0.88 and determination coefficients (R^2) from 0.60 to 0.78. The strongest performance was achieved for the Malta River at Viļāni, while the Malmuta River at Kažava exhibited greater variability due to the complex hydrology of swamp environments. Basin-specific calibration, particularly in the Malta and Malmuta basins, confirmed that tailored parameters—such as soil water storage, capillary rise, and snowmelt rate—significantly improved model performance. These findings validate the adaptability of METQ2007BDOPT for application in swampy and variable hydrological conditions. Refining swamp-related parameters enhances the model's predictive precision and supports its practical use in hydrological forecasting, climate impact assessment, and sustainable water resource management in the Baltic region.

Keywords: **Rainfall–runoff modelling; Model calibration; Validation; METQ; Swamp hydrology; Latvia.**

ET088

FORECASTS OF WASTE VOLUME AND FLOW DYNAMICS IN LATVIA IN THE CONTEXT OF EU WASTE MANAGEMENT POLICY

Alda Patersone, Alina Zotova, Jana Grave, Paula Miezaka, Anda Bakute, Jovita Pilecka-Uļčugačeva, Inga Grinfelde

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Jelgava, Latvia

The growing waste production in Latvia, driven by urbanization, rising consumption, and technological development, presents substantial challenges for achieving sustainable waste management. In alignment with the European Union's Waste Framework Directive and the Circular Economy Action Plan, Latvia aims to reduce landfill disposal to 10% of total waste by 2035, prioritizing prevention, reuse, and recycling. This study analyzes waste volume and flow dynamics in Latvia between 2018 and 2023 using data from national databases and the regional waste management company AAS Piejūra. The results reveal a steady increase in total waste volumes, from 3,439 tons in 2018 to 11,877 tons in 2023, with a sharp rise in 2020 linked to enhanced collection and processing systems. The largest waste fraction—mechanical processing residues—reached 7,223 tons in 2023, reflecting strong material recovery performance. Recycling of glass and paper showed consistent growth, while fluctuations in PET and used tire categories indicated gaps in collection infrastructure. The findings underscore Latvia's gradual progress toward a circular economy through improved recycling efficiency and expanded processing capacity. However, challenges remain, particularly in achieving EU landfill reduction targets and ensuring infrastructure resilience to seasonal fluctuations, especially in coastal regions. Strengthening public awareness, advancing sorting technologies, and increasing investments in recycling infrastructure are recommended to enhance sustainability and ensure EU policy compliance.

Keywords: **Waste management; Waste forecasting; Circular economy; Recycling efficiency; EU Waste Framework Directive; Latvia.**

ET089

LONG-TERM SPATIAL CHANGES IN AIR QUALITY IN JELGAVA CITY

Dženeta Veide, Paula Miezaka, Jana Grave, Inga Straupe, Jovita Pilecka-Uļčugačeva, Inga Grinfelde

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Jelgava, Latvia

Air pollution is a major environmental and public health challenge, particularly in densely populated cities. This study analyzes long-term spatial variations in air quality across Jelgava City, Latvia, using the Air Purity Index (I.A.P.), calculated from the distribution and frequency of sensitive lichen species. Lichens were applied as biomonitoring tools due to their high sensitivity to air pollutants and ability to capture both spatial and temporal trends at low cost. Field data were collected from 1,250 deciduous trees within systematically distributed plots representing varying urban land use types. Comparative analyses of surveys conducted in 1996, 2006, and 2016 revealed notable shifts in pollution intensity. In 2016, approximately 2.75% of Jelgava's urban area was categorized as highly polluted, 44.0% as moderately polluted, and 53.25% as clean. Improvements in air quality were observed in suburban and peripheral zones, while increasing pollution was noted in the city center—primarily due to intensified industrial activities and growing vehicular emissions. The results emphasize the vital role of urban green infrastructure in mitigating pollution, particularly in moderate- and low-pollution areas. However, persistent high-pollution hotspots continue to pose threats to biodiversity, ecosystem services, and public health. The findings confirm that lichen-based biomonitoring provides an effective, cost-efficient tool for long-term air quality assessment and environmental management in urban ecosystems.

Keywords: **Air quality; Bioindication; Lichens; Air Purity Index (I.A.P.); Urban sustainability; Jelgava City.**

ET090

SPATIOTEMPORAL ANALYSIS OF ZINC CONTAMINATION IN SNOW WATER AND ASSOCIATED ENVIRONMENTAL RISKS IN JELGAVA, LATVIA

Jovita Pilecka-Uļčugačeva, Viktorija Petrova, Alina Zotova, Maris Bertins, Inga Grinfelde

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Jelgava, Latvia, University of Latvia, Faculty of Geography and Earth Sciences, Riga, Latvia

Urbanization and increasing traffic intensity significantly contribute to heavy metal pollution in urban environments, posing potential risks to public health and ecosystems. This study investigates the spatiotemporal variations of zinc (Zn) concentrations in snow water within Jelgava, Latvia, from 2020 to 2024. A total of 59 sampling sites within the city and one control site in Mezciems were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to determine Zn concentrations and identify pollution sources. The results reveal substantial fluctuations in zinc levels over the study period, with peak concentrations recorded near high-traffic and residential zones. The highest measured Zn concentration (312.81 µg/L in 2024) indicates localized anthropogenic sources, including traffic emissions, domestic heating, and industrial activity. Average concentrations varied notably between years, from 1.28 µg/L in 2022—corresponding to post-pandemic reductions in mobility—to 13.39 µg/L in 2024, when mobility and heating-related emissions increased. Spatial analysis showed that transport corridors such as the A8 highway and Tērvete Street, along with railway infrastructure, exhibited the highest contamination levels. The study highlights that snow serves as a valuable passive bioindicator of urban air quality, capturing cumulative winter pollution from multiple sources. These findings emphasize the importance of continuous environmental monitoring and the implementation of pollution mitigation strategies. Recommendations include improved street cleaning, controlled snow management, integration of green infrastructure, and installation of filtration units in stormwater systems to reduce heavy metal loads. This research provides valuable insight into urban snowmelt contamination dynamics and offers a scientific foundation for sustainable urban planning and stormwater management in medium-sized Baltic cities.

Keywords: **Zinc contamination; Heavy metals; Snowmelt; ICP-MS; Urban environment; Traffic emissions; Environmental monitoring; Jelgava City.**

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