ICS25

INTERNATIONAL CONFERENCE FOR SUSTAINABLE RESOURCE SOCIETY

BOOK OF ABSTRACTS

THE 5TH INTERNATIONAL CONFERENCE FOR SUSTAINABLE RESOURCE SOCIETY

Climate Change, Resilience and Just Transitions

University of Eastern Finland
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UNIVERSITY OF EASTERN FINLAND
CLEHE
UEF RESOURCE RESEARCH COMMUNITY
UEF WATER
UEF FOBI FORESTS AND BIOECONOMY
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KUOPIO250

FOREWORD

The International Conference for Sustainable Resource Society (ICS) focuses on challenges of sustainability transitions in society, environmental change, and sustainable use of natural resources. The conference is jointly organized by the Research Communities of University of Eastern Finland: CLEHE, FOBI, PHOTONICS, RESOURCE and WATER that form interdisciplinary working groups including topics such as bio society, climate, water, energy & minerals, circular economy and sustainable society.

Held for the fifth time, the ICS Conference is strengthening its position as a regular event. The CLEHE (Climate Forcing, Ecosystems and Health) Research Community was honoured to coordinate the event this year. ICS25 was also an official part of the Kuopio250 anniversary celebrations.

The theme for ICS25, Climate Change, Resilience, and Just Transitions, brought together more than 200 participants from different disciplines that shared their research findings and engaged in discussions on global and local challenges related to environmental and climate change, sustainability transitions, and circular economy. A thorough understanding of the interactions between natural and human-induced emissions on climate and air quality, together with the influence of natural feedback mechanisms, is critical for designing effective mitigation strategies and implementing policies that protect environmental integrity and public health. This requires a multidisciplinary approach, which ICS25 was proud to host.

On behalf of CLEHE RC and whole organizing committee of ICS25

Kuopio 18.11.2025

Professor Anna Lähde
Head of the ICS25 Organizing Committee

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PROGRAMME

CONFERENCE DAY 1: Thursday, October 30

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10.00 - 11.00	**Plenary I**	Welcome to the conference: Plenary I	**SN100**
11.00 - 12.00	Lunch break		
12.00 - 13.40	**Parallel sessions I**	**Session 1.** Carbon capture, sequestration and utilization. KEYNOTE	**SN201**
		Session 2. Circular economy ecosystems	**SN203**
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		Session 4. Forests and bioeconomy	**SN205**
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		Session 6. Climate change, air pollution and green transition	**SN201**
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TIME (GMT+2)	ACTIVITY	PROGRAMME	BUILDING AND ROOM
16.00 - 18.00	**Poster session**		**Snellmania**
19.00 - 22.00	**Conference dinner**		Original Sokos Hotel Puijonsarvi

PLENARY I:

Welcome to the conference: Professor Anna Lähde, Head of the ICS25 Organizing Committee

Plenary: Eeva-Stiina Tuittila*, Deputy Head of School of Forest Sciences at UEF*

Eeva-Stiina Tuittila is as a professor of Forest Soil Science and Deputy Head at UEF School of Forest Sciences. She has strong background in plant and ecosystem ecology linking vegetation and microbial diversity and processes to soil carbon dynamics and greenhouse gas emissions. Major research questions are related to the peatland ecosystems, how they adapt and feedback to global change (climate change, changing management, restoration). Additionally, she is also interested how the ongoing change in humans' relationship to nature is impacting ecosystems and how it feeds back to humans.

CONFERENCE DAY 2: Friday, October 31

TIME (GMT+2)	ACTIVITY	PROGRAMME	BUILDING AND ROOM
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PLENARY II

Seppo Tossavainen is expert in international business with over 30 years of experience in exports, growth strategies, innovation ecosystems, and public-private partnerships. Currently, Seppo serves as the Head of Economic and International Affairs for the City of Joensuu. He has founded five companies, completed two successful exits, and held several executive positions both in Finland and abroad. Seppo's core expertise lies in the circular economy, bioeconomy, and cleantech, through which he has built global distribution networks in 25 countries. He established Business Finland's Canadian office in Toronto and led the North American bio- and circular economy Team Finland team. He holds Master of Science and MBA degrees in international business, as well as a Certified Board Member qualification.

ORAL PRESENTATIONS

2D carbon Additives for Low-Carbon Concrete: Sustainable Construction and Circular Economy Solutions

Shujie You[a], Heena Dhavan[a]

[a]Luleå University of Technology

The cement industry accounts for nearly 8% of global CO_2 emissions, making it one of the most significant contributors to climate change. Conventional Portland cement relies on energy-intensive clinker production, where limestone calcination requires 60–70% of the total energy consumed in cement production and releases large volumes of CO2. To support the green transitions and advance a sustainable built environment, alternative approaches are urgently required.

This study explores the use of 2D carbon additives to enhance the low-carbon cement's strength, aiming at further reducing the carbon footprint of concrete while preserving or enhancing performance. Additives investigated include graphene flakes and graphene oxide suspension. Laboratory-scale formulations were prepared by adding the additives into a low-carbon concrete mix with a constant water-cement ratio. Compressive strength, hydration kinetics, and microstructural development were evaluated; the assessment quantified CO_2 emission changes compared to reference low-carbon cement and ordinary Portland cement.

Results indicate that 2D carbon additives significantly alter the cement hydration's mechanical performance. Optimized additive blends can lower the consumption of cement while maintaining or improving mechanical performance and result in a deduction of CO_2 emission.

The findings point to the possibility of 2D-carbon additives and low-carbon cement as a scalable solution for reducing dependence on traditional clinkers. This approach contributes to climate change mitigation, circular economy goals, and more resilient construction practices.

Free-standing, hierarchical activated carbon granules for CO_2 capture

Praveen Wilson[a], Farid Akhtar[a]

[a]Luleå University of Technology

In the present work, we demonstrate the synthesis of composite granules by high-shear co-granulation of sawdust and polymer microspheres using polyvinyl pyrrolidone solution (2wt%) and polyvinyl alcohol solution (5wt%) as binders. By controlling the liquid binder-to-solid ratio and the granulator's chopper and agitator speed, composite granules in the size range of 4 to 8 mm were obtained, with nearly 70% accounting for granules in the size range of 5 to 7 mm. The composite granules were heat-treated (300 °C) and activated using KOH solution of various concentrations (0.5 M and 1 M) and activation temperatures (700, 800 and 900 °C). After activation, the sawdust-derived activated carbon granules (SCG) were in the size range of 3 to 5 mm and exhibited a BET surface area of 1458 $m^2\ g^{-1}$ and a pore volume of 0.73 $cm^3\ g^{-1}$. The BET analysis of the SCGs also showed a mixture of micro and mesopores, and the scanning electron microscopy revealed a hierarchical pore structure. The SCGs demonstrated a selective CO_2 capacity up to 3.8 mmol g^{-1} from a gas flow mixture composed of CH_4/CO_2 at 50 ml min^{-1} each. The work emphasizes designing structured activated carbon granules which can be used for practical applications.

Customer value creation in digital circular platforms - ecosystems perspective

Sini-Tuulia Suokas[a], Kaisa Henttonen[a], Ville-Veikko Piispanen[a]

[a]University of Eastern Finland

This qualitative case study encompasses Digital Circular Economy (DCE) company ecosystems from the value creation perspective. Overall, Circular Economy (CE) benefits green transformation and supports sustainable business ventures, functioning as an alternative for Linear Economy. For CE companies, ecosystems are crucial for building everyday functions. DCE operates on different digital platforms and builds their network through which exchanges occur. Customer is part of this ecosystem, among other crucial operators in it. The ecosystems have been of interest of CE literature and DCE makes no exception in this matter. Yet, customers' influence on the factor of value creation is still an under-researched area. Therefore, this study asks: "How ecosystems benefit from customer value creation in CE companies operating on digital platforms?" The research will be conducted with semi-structured interviews within an ecosystem of a DCE company, as a case study. The data is analysed with inductive content analysis, utilizing ATLAS.ti. The main outcomes and results will be acknowledging the customers' role and impact for the ecosystem, as a beneficial value creator. Understanding value creation in this complex totality of DCE will generate knowledge for the academic conversation of DCE and ecosystems and their relationship with the customer. This will be useful for business innovations and entrepreneurs building new CE ventures. The results will also benefit policymakers when operating towards sustainability goals.

Stakeholder perspectives on short-term rentals in the sharing economy: A media-based analysis from Finland

Kaisa Henttonen[a], Maria Hakkarainen[b], Salla Jutila[b], Jenna Päläs[a]

[a]University of Eastern Finland, [b]University of Lapland

This study explores how different stakeholders perceive short-term rentals within the broader context of the sharing economy (SE), particularly in relation to sustainability. While some scholars argue that SE business models promote sustainable development through economic, social, and environmental value creation, others caution that sustainability outcomes depend heavily on the specific social context. To investigate this tension, we analyze Finnish media coverage (YLE, Helsingin Sanomat, Kaleva, and Lapin Kansa) from 2020 to 2025, focusing on three urban centers: Rovaniemi, Oulu, and Helsinki. Our dataset includes diverse stakeholder voices—municipal authorities, housing companies, private landlords, and businesses—each offering distinct perspectives on short-term rental platforms like Airbnb. Authorities and housing companies emphasize regulatory challenges, neighborhood disturbances, and the need for clearer legal frameworks. In contrast, private hosts, customers and rental businesses highlight the economic advantages and flexibility these platforms offer. The terminology used to describe short-term rentals varies by stakeholder: officials tend to use formal terms such as “short-term accommodation” or “temporary rental,” while individuals and entrepreneurs predominantly refer to “Airbnb.” These linguistic choices reflect underlying attitudes and policy positions. Overall, the findings suggest that the sustainability of SE models like Airbnb is contested and context-dependent, shaped by stakeholder interests, regulatory environments, and local socio-economic dynamics.

Smart circular economy – systematic literature review on the role of digital technologies in circular product management in large organisations

Muhammad Zeshan Razzaq[a], Kaisa Henttonen[a], Ville-Veikko Piispanen[a]

[a]University of Eastern Finland

Digital technologies (DTs) are increasingly recognised as potential enablers of the transition from a linear to a circular economy (CE). However, much of the existing research has examined DTs in isolation, emphasising their role in process optimisation rather than exploring their integration across the entire product life cycle. As a result, the current body of knowledge remains fragmented, with limited empirical evidence to demonstrate the practical applicability of DTs in advancing circular strategies within manufacturing. Previous studies have investigated specific technologies such as the Internet of Things, Big Data, and Blockchain, yet their contributions remain largely theoretical and disconnected from systemic CE implementation. This study addresses these gaps by synthesising existing scholarship and empirical findings on the intersection of DTs and circular product management. It seeks to answer two key questions: (1) how and in what areas can DTs support the adoption and implementation of CE strategies across product systems, and (2) how can smart digitalisation enable circularity from design and development through to end-of-life processes such as recycling and disposal? By adopting a management-oriented perspective, the study highlights the role of DTs as enablers of radical circular innovations closely tied to business models, customer engagement, and inter-organisational collaboration. The review contributes by mapping the potential applications of DTs in manufacturing, identifying knowledge gaps, and proposing directions for future research to enhance their practical relevance for circular product life cycles.

Building Circular Plastic Ecosystems; Collaboration Dynamics and Strategic Specialization

Kristina Leppälä[a], Ville-Veikko Piispanen[a], Hanna Lehtimäki[a]

[a]University of Eastern Finland

The transition to a circular plastics economy is essential to mitigate pollution and unlock new business opportunities. Plastics production has surged globally since the 1950s, bringing both industrial utility and environmental ecosystem burden. Today, over 400 million tons of plastics are produced annually, with a significant portion terminating as waste.

The purpose of our study is to identify enablers of circular plastic ecosystems. Through evaluations of business models and value creation methods in companies, our research focuses on the Finnish plastics sector, examining seven plastics producers and six waste management companies through qualitative empirical analysis.

The findings show that key enablers include coordinated specialization, relational dynamics, innovation capacity, niche expertise, strategic alignment, and trust. As a research outcome we propose that these six elements form the foundation for a resilient and collaborative circular plastics ecosystem. This research contributes to understanding how systemic change towards a circular economy can be achieved in a fragmented yet opportunity-rich sector. As a practical implication we conclude that by fostering cross-sector collaboration and anticipating regulatory impacts and their impact on technology investments, the circular plastic economy in Finland can strengthen its position in global plastic recycling and export circular solutions.

Sustainable value creation in industrial ecosystems

Nuppu Mielonen[a], Hanna Lehtimäki[a]

[a]University of Eastern Finland

Industrial ecosystems are seen as subcategory of circular ecosystems. The industrial ecosystems are a set of independent yet interdependent actors in an industry context with sustainable resource usage, production and value creation are integral. With this research we aim to increase understanding of the sustainable value creation in an industrial ecosystem. More specifically, we are concentrating on the focal firms of the industrial ecosystems in their pivotal function of driving and living the larger sustainability vision. The role of the actors, and in more detail, the focal firms in an industrial ecosystem sustainable value creation remains ambiguous. This qualitative research focuses on two established real-life industrial ecosystems in the electric vehicle battery materials context. The empirical study is conducted in Kokkola Industrial Park (KIP), Finland, and Harjavalta Industrial Park (HIP), Finland. The empirical research material consists of primary material in the form of interviews with the focal firms and secondary material in the form of publicly available documents and online research. Our research contributes to existing literature by bringing new knowledge firstly on the role of the focal firm in sustainable value creation of an industrial ecosystem, secondly the sustainable value creation process of the focal firm in industrial ecosystem, and thirdly how the focal firms capture value to the industrial ecosystem.

Creating a Social-Circular Paradigm through Sustainability-Driven Entrepreneurship

Subhanjan Sengupta[a], Hanna Lehtimäki[a]

[a]University of Eastern Finland

Existing research on the circular economy strongly focuses on the much-needed technological solutions and innovation activities for resource efficiency in industrial systems. This inclination towards techno-centric emphasis, however, tends to overlook the interconnectedness between circularity and society, and how organizations operating close to the ground and in different sectors have the capability to make circularity socially meaningful. To address this gap, this study generates a dynamic understanding of how social sustainability and the circular economy are interconnected in the emergence of sustainability-driven entrepreneurship that combines social and circular practices. Based on empirical evidence from in-depth case studies in an industrialized global north country, we introduce a framework for social-circular value creation: a process of hybrid value creation that entails mechanisms of stacking social and circular benefits over time across organizational, inter-organizational, and societal levels. The results of this study contribute to the literature on the circular economy by conceiving a social-circular thinking that has profound policy and practice implications for including voices that are embedded in the micro-foundations of sustainability but remain at the periphery of progress that is concentrated in industrial systems.

Entrepreneurial Resilience in a Phasing-Out Industry: Survival Strategies of Finnish Peat Entrepreneurs in Systemic Transition

Juha P Kinnunen[a], Hanna Lehtimäki[a], Kristina Leppälä[a]

[a]University of Eastern Finland

The purpose of this research is to investigate resilience of peat entrepreneurs during the phasing-out of their industry as a part of the sustainable energy transition. Entrepreneurial resilience (ER) has been widely studied in the context of acute crises, yet less attention has been paid to industries undergoing long-term decline. Our study contributes to ER literature by exploring how resilience unfolds in a context of long-term institutional change. The research question we ask is how peat industry actor ER unfolds in the sustainable energy transition? Conceptually, we aim to better understand the antecedents and consequences of ER in the context of large-scale and long-term change. Also, we aim to consider the different roles of ecosystem actors to better understand the support mechanisms of ER. Empirically, we study peat entrepreneurs in two rural regions in Finland. The empirical material consists of 16 semi-structured interviews with a focus on interviewees´ experiences, coping strategies, and future outlooks. The results of our study show that in a long-term institutional sustainability transition emotional adaptation to inconsistent changes in government decisions, leveraging local and community-based resources, and maintaining well-being under pressure through diverse coping strategies constitute ER. Three main implications are discussed: First, an understanding of ER in a context of long-term change is significant to increase understanding of how entrepreneurs adapt emotionally, cognitively, and behaviourally over time in response to sustained adversity. Second, this study contributes to ER literature by deepening understanding of the relational aspects of support mechanisms for ER. Third, the results of this study increase our understanding of just transition by examining the sustainable energy transition from the perspective of those facing negative consequences due to large-scale green projects. As a practical implication, these insights are essential for designing supportive policies that promote long-term social sustainability and human-centered development in work life.

Value-Focused Thinking for Circular Economy Transitions: A Case Study of the Stakeholder Values

Lauri Kurkela[a]

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This paper examines how value-based decision-making can accelerate the transition to a circular economy (CE) by identifying stakeholder values and translating them into concrete objectives. Study focuses on urban food system and what values stakeholders hold regarding the system.

Using a structured framework for Value-Focused Thinking (VFT), this paper explores what values and objectives can be identified. The research questions are: "How does the structured VFT method work to identify values and actions for a local circular food system?" and "Can the use of values lead to a stronger form of a circular economy?". The literature on CE and sustainability transitions has highlighted the lack of a social perspective in decision-making. Integrating values into this process can incorporate the social dimension, but this is only possible if stakeholder values are first identified. Therefore, interviewing stakeholders and analysing their values helps to reveal concrete objectives that reflect those values, thereby fostering a more socially sustainable transition. Furthermore, previous explorative research has utilized VFT to generate innovative solutions and identify stakeholder values for local circularity transitions. However, existing research implies that current actions towards CE only support a weak form of circularity and fail to catalyse the transition away from the linear economy at the necessary pace. This study is designed as a case study of Espoo's Kiviruukki district, which is planned to be a global frontrunner in sustainability and the circular economy.

The framework of this paper demonstrates the importance of values for the circular transition in creating concrete, value-focused objectives for the local food system. Additionally the results indicate whether the VFT framework can reveal actions for stronger circularity and catalysing the local sustainability transition at higher pace than previous methods.

Strategic Drivers and Adaptive Capacity in Open Innovation: Evidence from Vietnamese Manufacturing SMEs

Tarlan Ahmadov[a], M. Nguyen Quang[b]

[a]University of Eastern Finland and Finnish Environment Institute, [b]University of Valencia

This study explores how strategic drivers—entrepreneurial orientation and proactive environmental strategy—affect open innovation practices in resource-constrained small and medium-sized enterprises (SMEs), focusing on the mediating role of adaptive capacity. Utilizing data from 122 manufacturing SMEs in Vietnam, the research applies partial least squares structural equation modeling (PLS-SEM) to examine the direct and mediating effects of these strategic drivers on open product and process innovation, and their subsequent impact on both economic and environmental performance outcomes. The findings reveal that a proactive environmental strategy significantly enhances adaptive capacity and drives both open product and process innovation, while entrepreneurial orientation predominantly promotes open process innovation but does not significantly influence adaptive capacity. Notably, adaptive capacity partially mediates the effect of proactive environmental strategy on open product innovation, but no significant mediating role is observed in other paths. Furthermore, open product innovation, rather than open process innovation, emerges as the critical determinant of economic and environmental performance in these SMEs. The results highlight the importance of context-specific strategies in building dynamic capabilities for sustainable competitiveness among SMEs in developing economies. This study contributes to the open innovation and dynamic capabilities literature by clarifying the mechanisms through which strategic orientations and adaptive capacity shape innovation outcomes and firm performance in emerging markets.

Promoting climate policy integration in privately owned forests: How to foster policy acceptance?

Samuli Pitzén[a]

[a]Finnish Environment Institute

Forests play a central role in Finland's climate policy. Recent calculations by the Natural Resources Institute indicate a decline in national carbon sinks, jeopardising Finland's ability to meet its EU climate commitments. This underscores the need to reassess current forest management practices and explore new approaches to climate action in forestry. Policy integration refers to the alignment of traditionally separate policy domains—such as forest and climate policy—by bridging institutional silos and fostering coordinated governance. In practice, this involves incorporating climate mitigation and adaptation goals into forest policy through targeted instruments. Yet, the outcome of such integration depends heavily on policy acceptance, particularly in Finland, where 60% of forests are privately owned. This study examines forest owners' acceptance of novel economic policy instruments aimed at enhancing carbon sequestration and storage. Based on a nationwide 2023 survey (N = 2,137), we identify groups of both critics and supporters of climate policy integration. We focus on those who are hesitant but potentially willing to participate in the economic compensation schemes under certain conditions. Specific choices in the policy design, such as including an insurance for forest damage, could foster policy acceptance. In addition, general information guidance and negotiation of knowledge disagreements are key to building mutual trust and understanding. These findings emphasise the importance of considering policy acceptance to promote better policy integration outcomes.

Towards Strongly Sustainable Business Model: A Systematic Scoping Literature Review

Mirkka Rovamo[a], Anu Laakkonen[a], Katri Rusanen[a], Jani Holopainen[a]

[a]University of Eastern Finland

Climate change and the loss of biodiversity pose a serious threat to human well-being and to business sectors that rely on natural capital, such as the forest sector. These challenges underscore the urgent need for a transition toward strong sustainability thinking, according to which, natural capital is considered non-substitutable by man-made capital. Moreover, the environment sets limits to the well-being and growth of society and the economy.

We conducted a systematic Scoping literature review with two primary objectives. First, we aim to deepen the understanding of the concept and dimensions of strong sustainability and its evolution over time. Secondly, we introduce a framework for strongly sustainable business model. This framework combines existing research on strongly sustainable business models with perspectives from other business-related strong sustainability literature.

Our findings reveal that research areas around strong sustainability is wide including themes related to business, economy, environment and sustainability. However, despite nearly four decades of research on the concept of strong sustainability, its practical applications remain limited. As business models serve as important tools for organizations to articulate and operationalize their value propositions, in our proposed framework, we underline the importance of nature as a core value and a primary stakeholder, forming the foundation for strongly sustainable business operations.

Our proposed framework for strongly sustainable business model functions as a design tool aimed at translating the principles of strong sustainability into practice. In our forthcoming research we will apply this framework within forest environments through interviews aimed at companies operating with forest ecosystems. Furthermore, we intend to test the model in the context of forest service planning, thereby providing empirical evidence and concrete examples of how strongly sustainable business model can be operationalized in the forest sector.

Reducing greenhouse gas emissions with heavy-duty liquefied biogas (LBG)-powered vehicles in long-distance road transportation of forestry products

Sami Huusko[a], Kalle Kärhä[a]

[a]University of Eastern Finland

Decarbonization of the supply chain of forestry products is essential as sustainability of the end products is becoming an important factor. Forestry operations are generally a difficult area to decarbonize as there are limited low-carbon options available. For instance, the forestry machines currently almost completely rely on fossil-based fuels. On the other hand, there are a few alternatives available on road transportation.

One option is usage of alternative fuels of which biogas and electricity have vehicles already available on market. However, these vehicles have limitations such as lower operational range, lower engine power, gross vehicle weight (GVW), and sparse refueling/charging infrastructure. Electric vehicles also suffer from longer charging times. Therefore, electric heavy-duty (GVW > 60t) vehicles are not viable yet, especially on the longer transportation distances operating with the lower-class road network far away from the infrastructure.

Liquefied biogas (LBG)-powered heavy-duty vehicles have been available for a longer period and were recently updated to have maximum GVW of 75 tonnes which is comparable to diesel-powered vehicles with maximum GVW of 76 tonnes. LBG-powered vehicles have been found to decrease Well-to-Wheel carbon dioxide equivalent emissions by 44.6% per tonne-kilometer compared to diesel-powered counterparts when the default emission factor provided by ISO 14083:2023 standard were utilized. LBG-powered vehicles were also found to have similar cost-efficiency as diesel-powered vehicles. Therefore, LBG-powered vehicles can cost-effectively reduce carbon footprint of the forestry products significantly, even in the challenging operating conditions.

Identifying Undelayed Emission Reduction Potential from Fuelwood Use

Yang Xu[a], Henrik Herajärvi[a], Adam Taylor[b]

[a]University of Eastern Finland [a]University of Tennessee

Wood energy reduces fossil emissions through substitution, a benefit quantified by the displacement factor (DF). However, this climate benefit of fuelwood is contested, primarily due to uncertainties in temporal aspects (e.g., carbon debt dynamics), At the same time, existing DF estimates are limited by inconsistent life-cycle assessment (LCA) boundaries and a scarcity of available data across countries and regions. This study overcomes these challenges with a framework that derives the DF directly from IPCC-standardized emission factors (EFs), based on a market-share model. The model assumes that if wood were not used, its energy function would be replaced by a mix of alternative fuels proportionate to their current market shares. A key finding is the identification of a critical emission factor threshold of 0.43 tCO_{2e}/MWh. When the EF of the alternative fuel mix exceeds this value, the DF surpasses 1, indicating that fuelwood use achieves undelayed net emission reductions during the combustion phase. Combing this threshold with 2021 energy consumption data from the EU-27, we identify 6 countries (Austria, Bulgaria, Cyprus, Germany, Poland and Sweden) and 12 application sectors, including heat plant, wood and wood products, transport equipment, and iron and steel, which showed significant potential for undelayed emission reduction through fuelwood substitution. It's recommended that wood energy policy be prioritized in these sectors to maximize climate benefits.

Leveraging Open-Source Data and AI for Soil Health Assessment and Sustainable Agriculture

Danish Mustafa Khan[a], Zunaira Iqbal[a]

[a]Earth Warriorz

Sustainable agriculture requires timely insights into soil health, yet on-the-ground measurements can be costly and labor-intensive. This project proposes an innovative, data-driven approach using open-access soil, climate, and satellite datasets to assess soil fertility, nutrient status, and degradation risks. AI and machine learning models are applied to analyze these datasets, identify patterns, and predict nutrient deficiencies and crop performance across different regions. By integrating geographic, climatic, and soil information, the system generates actionable insights for precision fertilization, crop planning, and resource optimization. This methodology eliminates the need for experimental lab trials, enabling scalable, low-cost, and regionally adaptable solutions. The project highlights the potential of combining AI with open-source environmental data to support sustainable land management, climate resilience, and decision-making for farmers and policymakers worldwide.

Seasonal and Temporal Variability of Nitrous Oxide Emissions in a Clay Loam Agricultural Soil

Karuna Rao[a],Markku Koskinen[a], Annalea Lohila[b], Alexander Buzacott[a], Mika Korkiakoski[b], Henriikka Vekuri[b], Tatu Polvinen[a], Mari Pihlatie[a]

[a]University of Helsinki, [b]Finnish Meteorological Institute

Agricultural soils are the largest anthropogenic source of nitrous oxide (N_2O), a potent greenhouse gas and ozone-depleting substance. Here we present the seasonal and diurnal variability of N_2O fluxes and the flux drivers in an agricultural ecosystem at the SMEAR-Agri Viikki site, Helsinki, over two years. The site was cultivated with timothy (Phleum pratense) in 2022, which was renewed in the spring 2023 with a mixed crop of barley (Hordeum vulgare), red clover (Trifolium pratense), and grasses. The lowest flux has been observed during the winter in both the year with the mean value of 0.63±0.42 mg m−2 d−1 in 2022 and 0.70±0.63 mg m−2 d−1 in 2023. The highest flux, in 2022, was observed during late spring and early summer whereas in 2023, the highest fluxes were observed during autumn, right after the harvest of barley (2.45±2.5 mg m−2 d−1). The N_2O emissions in 2022 showed no clear seasonal trend, while multiple but smaller emission peaks occurred in 2023. Soil moisture, water-filled pore spaces (WFPS), and both soil and air temperature were the primary meteorological drivers of N_2O variability during spring, summer and autumn seasons, while during winter season N_2O flux shows decoupling (no correlation) from the meteorological drivers. Principal component analysis (PCA) further indicated that soil conditions exerted a strong seasonal influence: surface soil moisture and temperature controls dominated in spring and summer, deeper soil water–redox interactions were important in winter and autumn. These findings highlight the seasonal complexity of N_2O dynamics and underscore the importance of accounting for both soil conditions and seasonal context when assessing and mitigating emissions from agroecosystems.

Quantification of dynamic nitrous oxide emissions post-fertilization using laser dispersion tomography

Kenneth Scheel[a], Aku Ursin[a], Damien Weidmann[b]

[a]University of Eastern Finland, [b]STFC Rutherford Appleton Laboratory

Nitrous oxide (N_2O) is an abundant greenhouse gas (GHG) and contributes significantly to global warming. Almost 70% of anthropogenic N_2O emissions in 2023 were due to agriculture, primarily driven by increased use of N-fertilizers. In the soil, N-fixing bacteria convert the added N into N_2O. The assessment of N_2O emission rates from individual sources is highly uncertain because commonly used measurement techniques have limitations. Accumulation chambers provide data only from very small areas and are unsuitable for continuous monitoring, while the Eddy covariance technique assumes a spatially homogeneous land area and provides only ecosystem-level averages. As emissions-reducing fertilization practices are being developed, methods for quantifying N_2O emissions are becoming increasingly important.

In this work, we use a novel laser-based tomographic approach for dynamically quantifying and mapping GHG emissions on an agricultural field scale. The technique uses a rotating laser dispersion spectrometer (LDS) to sequentially scan a set of retroreflectors installed in the field, collecting path-integrated concentration measurements along multiple laser beam-paths in areas up to 1 km². Time series of path-integrated concentrations together with wind field measurements are then incorporated into simultaneous reconstruction of spatiotemporally distributed concentration and sources/sinks of the GHG.

In this study, laser tomography of N_2O is validated numerically and experimentally. While the technique has previously been applied to detecting point sources or quantifying otherwise spatially constrained sources, the present numerical simulation study demonstrates the suitability of laser tomography for estimating diffuse sources and sinks – such as those associated with N_2O emission and sequestration in agricultural fields. The experimental data was acquired in an N_2O monitoring campaign at a farm in the UK, where N_2O concentrations were measured from two fields after fertilization. The post-fertilization source/sink-dynamics of the fields are reconstructed, shedding light on how N_2O emission patterns change in response to fertilizer application.

Timing of grass renewal regulates nitrous oxide emissions from a drained boreal peatland

Sanni Semberg[a], Hem Raj Bhattarai[a], Petra Manninen[a], Yuan Li[a], Narasinha Shurpali[a], Perttu Virkajärvi[a]

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Drained boreal peatlands have been used for forage production for decades and they are known sources of nitrous oxide (N_2O). Grassland renewal is a common management practice to maintain high forage productivity and quality, although renewal by ploughing is known to increase N_2O emissions. We measured N_2O fluxes over three years from two grassland renewal strategies: autumn ploughing with reseeding the following spring (AP), and summer ploughing followed by prompt reseeding (SP). We used manual chambers for measuring fluxes during snow-free seasons and snow gradient method during the snow-covered periods.

Over the three-year study period, AP emitted 2.6 times more N_2O than SP. The highest increase in cumulative emissions was seen in AP after ploughing and again after reseeding and fertilization, and in SP after ploughing and reseeding. This suggests that the management practices had a strong effect on the N_2O flux rates and annual emissions. In addition, we found the grassland renewal to increase yields compared to prior renewal, regardless of the renewal timing. Yield-scaled N_2O emissions were significantly lower in SP compared to AP, suggesting SP could be an effective mitigation strategy for N_2O emissions in boreal organic soils. However, to fully assess the climatic impact of summer renewal practice, the emissions of carbon dioxide and methane need to be addressed as well.

It is important to consider the trade-off between agricultural productivity and N_2O mitigation in forage production, particularly in northern latitudes where ruminant-based systems are the main source of dietary protein. Given the high global warming potential of N_2O and the relatively large contribution of drained organic soils to agricultural greenhouse gas emissions, our findings offer insights that are highly relevant to climate change mitigation in northern grassland ecosystems.

Drought effects on nitrogen cycling and N_2O emissions under different cover crops in a controlled experiment

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Cover crops are recognized as a climate-smart agricultural practice that increases soil organic carbon content (SOC). As carbon (C) and nitrogen (N) cycles are coupled, an increase in SOC can impact the N cycle and nitrous oxide (N_2O) emissions. Another major driver affecting N cycling and N_2O emissions is soil moisture. With the increasing risk of summer droughts and wetter conditions during the off-season in Northern Europe, it is important to understand how drying-wetting and agricultural practices together affect N cycling and N_2O emissions.

To address this knowledge gap, we conducted a pot experiment with clay soil in controlled greenhouse conditions simulating summer drought with bare soil pots and oats sown either alone, with Italian ryegrass, or with alfalfa as plant treatments. The pots were initially watered to 70% degree of saturation to ensure that the plants start to grow, after which half the pots were let dry to 40% degree of saturation. The plants were grown for 36 days. After the growth period, soil N_2O emissions were measured over three days. Following this, the pots were sampled destructively, and total N in plants, roots, and soil, as well as mineral N in soil, were analysed.

Contrary to our expectations, the results from the pot experiment showed that N_2O emissions in the plant treatments were higher in drought conditions than in moist conditions. This does not support our results from a cover crop field trial where reduced rainfall did not affect N_2O emissions during the growing season. The presence of plants decreased soil N_2O emissions, but the plant species did not affect the emissions nor the total mineral N content in soil. As expected, total mineral N content in soil was higher in drought conditions than in moist soil as well as in bare soil compared with soil with plants.

Luke Ruukki infrastructure – Water Management Innovation Living Lab

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In the Water4All project Water-Oriented Living Labs (WOLLs) are mapped both in Europe and globally. WOLLs are real-life, water-focused demonstration or platform-type environments that utilize a cross-sectoral approach. They engage and involve multiple stakeholders and provide so-called "field laboratories" for the development, testing, and validation of solutions. These solutions include technologies, their integration, and their combination with new business models and innovative practices based on the value of water.

The Ruukki experimental station of Natural Resources Institute Finland (Luke) was established 1925 and it is Luke's northernmost agricultural station. The North Ostrobothnia area is known for its intensive milk and beef production and the large share of cultivated peatlands. The station includes a cattle barn for beef production research. The research activities focus on peatlands under various land uses, acid sulfate soils, the cultivation of grass and feed grains, and the practice of sustainable agriculture in northern conditions.

Agricultural water management has become a strong focus area, emerging as one of the key priorities at the Ruukki experimental station. As a result, Ruukki was proposed as one of the Water-Oriented Living Labs (WOLLs).

Ruukki's WOLL is named the Water Management Innovation (WMI) Living Lab. It serves as a pioneer in sustainable agricultural water management in northern conditions. Ruukki focuses on the development and testing of environmentally friendly, socially responsible, and economically viable solutions. It utilizes real-time data and advanced sensors to monitor and manage water quality and availability, enabling data-driven decision-making for farmers.

Ruukki's research infrastructure is significantly developed by constructing modern research facilities and investing in state-of-the-art measurement equipment. Research activities have become increasingly international, e.g. by opening research platforms to external collaborators.

Active stakeholder engagement promotes shared understanding and the adoption of best practices in water management, highlighting Ruukki's role in advancing sustainable agriculture through innovation and collaboration.

Obstacles to Integrated Governance of Climate Change and Air Pollution in the EU: The Neglected Vertical Dimension

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Policy integration is a key principle for EU environmental governance, including between climate and clean air policies. As causes of global warming and air pollution overlap, synergistic approaches tackling both issues exist. Yet not all ways of cutting carbon also reduce pollution, and some pollutants have cooling effects – so trade-offs link these fields, too. The European Commission, the highest authority for EU climate and clean air policymaking, thus promotes an integrated approach to these issues that maximises synergies while minimising trade-offs. Its Green Deal strategy demands integration between environmental policies to reach zero-pollution and climate-neutrality by 2050.

However, integration mustn't stop at strategies' definition, but continue throughout their implementation. The Commission must choose appropriate instruments to deliver promised synergies – and lower levels of governance, who enact them, must follow suit. This vertical dimension, linking upstream policymaking to downstream implementation, is neglected in policy integration literature. Yet it is crucial: Evaluating integration between climate and clean air policies on different governance levels – in EU-, national-, and urban-level policies – I found that their approaches vary widely in quality, often falling short of Green Deal ambitions. Hence, the Commission's push for integrated policies does not fully translate to lower levels of governance. The link between horizontal and vertical integration is broken.

I will present this case comparison and initial findings on the reasons behind lacking policy integration at the implementation stage. Case jurisdictions are Italy and Finland on the national level, with Milan and Helsinki on the local level. Besides the comparison, I draw insights from multilevel governance theory and interviews with experts and policymakers from each analysed jurisdiction. Successful sustainability transitions require contributions from all governance levels, so my findings fill crucial gaps in policy integration research.

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Emissions and indoor air pollution from cookstoves: insights from rural Nepal and controlled laboratory studies

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Indoor air pollution is a major public health challenge in many low- and middle-income countries, where households rely on biomass fuels for daily cooking. Women and children are particularly exposed, as they spend more time indoors and near cookstoves. In Nepal, household air pollution is related to over 33 800 premature deaths annually.

In this study, we conducted extensive field measurements in rural Nepalese households across different regions and laboratory experiments in small-scale combustion simulator (SIMO) at the University of Eastern Finland following Water Boiling Test protocol version 4.2.3. In SIMO, various emission parameters were measured from flue gas, including black carbon (BC), carbon monoxide (CO), total hydrocarbons (THC) and PM2.5 filter samples. In both Nepal and SIMO, indoor air concentrations were measured using same devices capturing PM2.5, ultrafine particle number, BC and CO concentrations, and volatile organic compound (VOC) samples. Polycyclic aromatic hydrocarbons (PAH) were analysed from collected samples. In addition, survey and interview campaigns explored household stove and fuel choices, user practices, and related socio-economic and cultural factors.

Laboratory experiments provided detailed emission factors and allowed us to examine how stove design influences emissions and indoor air quality. Field measurements and survey and interview campaigns conducted in Nepal, together with laboratory experiments in Finland, demonstrate that current cooking practices lead to significant indoor air pollution and high exposure to harmful pollutants. These findings emphasize the urgent need to change existing practices. Effective reduction of exposure requires integrated approaches that combine improved stove technologies, better ventilation, informed user practices, and consideration of socio-economic and culturally appropriate solutions.

A Detailed assessment of catalytic reduction of organic emissions from a wood stove using PTR-ToF-MS

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Residential wood combustion (RWC) is a major source of harmful air pollutants, including black carbon, polycyclic aromatic hydrocarbons (PAHs), carbonyls, and volatile organic compounds (VOCs), which degrade air quality and impact human health and the environment (Hartikainen et al., 2020). RWC is the largest source of organic aerosol in Europe, with VOCs contributing substantially to secondary organic aerosol (SOA) formation. Increasing awareness of these impacts has led to stricter European regulations, such as the Eco-design directive and the Blue Angel ecolabel.

An experimental campaign was carried out to characterize emissions from a modern wood log stove (Tulikivi) equipped with a catalytic converter. Gaseous emissions were measured using a dual Fourier-Transform Infrared (FTIR) spectroscopy setup positioned pre- and post-catalyst, while detailed VOC analysis was performed with a Time-of-Flight Proton-Transfer-Reaction Mass Spectrometer (PTR-ToF-MS, Ionicon). Additional monitoring included CO, total hydrocarbons (THC), and NO with single gas analyzers.

The highest emissions occurred during cold ignition, followed by the hot ignition phase. The catalyst significantly reduced CO emissions: from 1603 to 1011 ppm (37% reduction) during cold start, and from 2406 to 874 ppm (64% reduction) during hot start. Flaming phases consistently showed around 60% CO reduction, linked to increased catalyst temperature and enhanced conversion efficiency. Total hydrocarbons also declined by up to 34%, with reductions strongly dependent on combustion phase.

VOC data revealed that aliphatic hydrocarbons and carbonyls dominated organic gaseous emissions under all conditions. Emissions peaked during cold start but decreased as the catalyst reached operating temperature. While carbonyls and aliphatics remained significant post-catalyst, the overall findings confirm the catalyst's ability to substantially mitigate gaseous pollutant emissions from residential wood combustion.

Electrospun $SrCl_2$–carbon nanofiber composites for safe and efficient ammonia-based energy storage

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To limit global warming to 1.5°C by 2050, a drastic reduction in greenhouse gas emissions and a transition to low-carbon, efficient, and safe energy systems are essential. Among the emerging energy carriers, ammonia (NH_3) is distinguished as a carbon-free chemical fuel that can be stored and transported using existing infrastructure. Nevertheless, serious safety concerns arise due to its toxicity and high vapor pressure in its liquid form.

A viable solution to these challenges is solid-state ammonia storage. In particular, alkaline earth metal halides such as strontium chloride ($SrCl_2$) can be used to create stable metal ammine complexes ($Sr(NH_3)_8Cl_2$) through a chemisorption process, enabling high NH_3 uptake and reduced toxicity. However, $SrCl_2$ as a bulk undergoes significant volume expansion during sorption, resulting in mechanical instability and low desorption kinetics. To address these challenges, innovative sorbent composites have been developed. Among them, carbon nanomaterials are recognized for their high surface area and thermal conductivity, demonstrating significant potential as structural reinforcements.

In this research, we present a novel approach for synthesizing $SrCl_2$–carbon nanofiber composites (SrCs) using electrospinning and a three-step carbonization process. Polyvinylpyrrolidone (PVP) served as a carrier polymer in a water/ethanol solution and as a carbon precursor, enabling high $SrCl_2$ loadings (up to 90 wt%) while preserving structural integrity. The resulting composite materials exhibit a stable ammonia uptake of 671 mg/g throughout four sorption/desorption cycles, in addition to enhanced desorption kinetics and mechanical integrity. These findings support the development of next-generation energy carriers and contribute to the broader sustainability transition by enhancing material performance and process safety.

Novel compositionally complex alloys to increase the safety during transportation and storage of pressurized hydrogen

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The transition from fossil fuel-based societies towards greener energy systems relies, to a large extent, on the exploitation of hydrogen as a clean energy carrier. Therefore, efficient and safe hydrogen storage and transportation are areas of great interest. Compositionally complex alloys, with five or more principal elements in relative concentrations within 5-35 at.%, exhibit a reduced reactivity with hydrogen at low and moderate temperatures thanks to the configurational entropy stabilization and the sluggish diffusion effects. In this study, the hydrogenation behavior of a near-equiatomic Ti-V-Zr-Nb-Mo-Hf-Ta-W refractory high-entropy alloy (R-HEA) has been thoroughly investigated. After adequate thermal activation, this alloy exhibited a hydrogen uptake capacity of 1.13 wt.% H after exposure to a pure H_2 atmosphere at 350 °C and 60 bar for 6 h. X-ray diffraction analyses revealed the presence of (Hf,Zr)-mixed oxides at the surface of this compound, which has been identified as the main reason for the relatively low H uptake and the extremely slow H absorption kinetics. Moreover, immediate re-oxidation of this alloy was observed upon exposure to the air atmosphere after hydrogenation. The results of the present study suggest that R-HEAs containing strong oxide-forming elements such as Ti, Zr, Hf, or even W can be used as novel, self-regenerating hydrogen permeation barriers in the case of intermittent exposure to pressurized H_2.

Litigating a just transition: Legal disputes over wind energy in Finland

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The transition to low-carbon societies creates both winners and losers, fuelling perceptions of injustice. Litigation is increasingly being used as a tool to challenge these injustices, targeting laws, policies, and projects designed to advance the energy transition. In Finland, this trend is particularly evident in the wind energy sector, where rapid expansion has been met with declining local acceptance and an increasing number of complaints filed in administrative courts. While litigation may pose significant challenges to Finland's wind power expansion plans and delay the transition, the phenomenon remains poorly understood. Building on the working definition of 'just transition litigation' developed by Savaresi and others in their 2024 Nature article 'Conceptualising Just Transition Litigation,' this study is among the first attempts to systematically analyse the emerging phenomenon of litigation specifically concerning wind power. It explores the extent to which complaints to Finnish administrative courts challenging wind power projects can be understood as just transition litigation, as well as the key characteristics of these complaints and the justice claims they raise. Using content analysis, the study examines various aspects, including the identity of applicants, the geographic distribution of complaints, the types of decisions challenged, the justifications and legislative basis of the complaints, the claims raised, the outcomes and success rates, the escalation to the Supreme Administrative Court, and the justice frames reflected. The analysis reveals that just transition litigation is widespread within Finland's wind energy sector, with the majority of complaints falling under this concept. It is driven by a complex interplay of concerns that draw on various justice principles and encompass diverse perspectives and motivations.

The Historical Development of Energy Efficiency in EU Law and the Emergence of Energy Efficiency First Principle

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A decade ago, the EU declared the prioritization of energy efficiency in its energy policy leading to the adoption of the Energy Efficiency First principle (EE1 principle). It is a novel principle aiming to guide the EU towards climate neutrality while strengthening the EU's energy security. Despite the existing research on the EE1 principle, its status and practical application remain unclear. This article adds to the previous research on the EE1 principle by analyzing its emergence using historical legal method. In this way, the research topic also contributes to the broader scholarly discussion on how principles are formed in EU law and in EU energy law specifically. The EE1 principle did not emerge in a vacuum but it had a strong foundation in the EU legislation on energy efficiency. Therefore, the research question of the paper is: how has energy efficiency developed in EU law? The paper argues that it required 50 years of legislative development on energy efficiency in EU law for Energy Efficiency First principle to emerge. Without these historical legal developments of EU law, the EE1 principle would not have emerged. The paper analyses the evolution of energy efficiency in EU law since the 1970s when rational use of energy emerged in the Community's energy policy. The focus is on key trends in legislative and policy developments on energy efficiency. These developments are analyzed through the lens of different themes that have contributed to the molding of energy efficiency in EU law, including, energy security, internal market, environment, climate change, competitiveness and the consumer.

EU decarbonisation in times of crises: an overview of multilevel governance gaps for an equitable twin transition

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This presentation discusses the complex challenges of the European Union's (EU) twin transition which is reshaping societies, economies, and infrastructures at every level of governance. This research identifies the gaps in the existing Multilevel Governance (MLG) framework guiding the twin transition and proposes tentative solutions that pave the way for an equitable transition.

The EU's commitment to carbon neutrality by 2050 recognises the pivotal role of the green digital transition in achieving sustainability, fairness, and competitiveness, emphasising the need for proactive and integrated governance to unlock its potential and mitigate adverse effects. However, the gap between inclusive and sustainable MLG frameworks and a just twin transition in a crisis-ridden world is wider than ever. In other words, the current MLG framework has to adapt to twin transition aims. The COVID-19 pandemic led to shifts in national priorities, temporarily favouring high-polluting energy sources like coal over sustainable renewables. At the same time, the Russian invasion of Ukraine heightened energy concerns and, in several cases, led to a focus on domestic sources, especially coal. Divergent policy responses among member states highlight the complexity of the EU's twin transition agenda, emphasising the need for innovative MLG frameworks, cross-border collaboration, and coordinated strategies at various levels of governance. Transitioning to a green future requires significant changes to institutions historically tied to fossil fuels and limited levels of digitalisation. This presentation focuses on a shift from top-down decision-making to a more inclusive, democratic approach involving various levels of governance, including governments, businesses, and civil society. This presentation discusses the requirement for the improvement of MLG to strengthen democratic governance in the EU and ensure a just twin transition.

In sum, we aim to present the objectives and preliminary results of an early-stage Horizon Europe project, DeCrises, on the MLG of the EU twin transition.

Geological Knowledge, Institutions and Materiality in the Construction of the Promise of Safe Geological Disposal of Spent Nuclear Fuel

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Within the international 'nuclear community', geological disposal is generally accepted as the preferred option for safe management of high-level radioactive waste. This promise is vital for the affected potential host communities but also for the nuclear sector, whose survival hinges on its ability to demonstrate a credible solution to the enduring 'waste problem'. Drawing on the sociology of expectations, notably on the concepts of the economy of techno-scientific promising, we examine the construction of the promise of safe geological disposal. Through the case of Finland, poised to become the world's first country operating a deep geological repository, we illustrate the political nature of geological knowledge and its entanglement with the discursive, institutional and material dimensions of the promise.

We apply these premises to a longitudinal qualitative document analysis of the Finnish repository project from the 1970s up until the present. The waste management company Posiva – owned by the nuclear utilities TVO and Fortum – is currently awaiting green light from the nuclear safety authority and the government on its operation licence application. Drawing on material from Posiva and TVO, focusing on three key phases in the repository siting and licensing process, we demonstrate how the role of geological knowledge has co-evolved with the discourses, institutions and materialities that make up the waste disposal promise. The article contributes to scholarship on techno-scientific promises by highlighting simultaneous stability and constant requalification of the promise, and the evolving political nature of geological knowledge in the construction of the waste disposal promise.

System Dynamics for Circular Economy: Critical Raw Materials in the Energy Transition

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The transition toward sustainable energy systems and the rapid growth of the battery industry highlight the importance of understanding the dynamics of critical raw materials such as lithium, cobalt, nickel, copper, and rare earth elements. System dynamics (SD) modelling offers a powerful framework for exploring interdependencies and generating insights to support informed policy and industry decisions.

We study the existing SD models developed at TU Delft, VTT, and other research groups to examine how circular strategies may influence material sufficiency and business viability. Case studies include copper (Auping, 2011), cobalt (van der Linden, 2020), nickel (Bradley, 2021; Slotte et al., 2023), lithium (van Essen, 2022; Lähdesmäki et al., 2023; Granvik et al., 2025), and rare earth elements (Besselink, 2024). These models demonstrate a range of methodological approaches, from disaggregating supply at the level of individual mines to incorporating circularity extensions and substitution pathways. Policy scenarios in the models illustrate how reuse, remanufacturing, and recycling can shift system trajectories, but also how outcomes depend on substitution limits, market dynamics, and coordinated regulation.

By synthesizing insights across multiple SD applications, we emphasize the value of system dynamics as a unifying tool for assessing circular economy strategies in raw material-intensive industries.

Perspectives on land use governance of utility-scale solar power development in Finland

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Utility-scale solar power production is an emerging and rapidly growing sector in Finland. There are no established practices for its land use governance. Land use steering practices vary across municipalities, and a nationwide perspective on the appropriate level of land use regulation is only beginning to take shape as legislative reforms are underway. This study identifies needs and challenges in land use governance of utility-scale solar power development in Finland and discusses their implications on developing sustainable land use governance practices for such development. The data of the study draws on interview data of land use planners and experts (n=24) from five different regional federations, and regional and national level state administration in Finland. The study contributes to understanding of land use needs and challenges and their governance in energy transition with a focus on solar power.

CEO's education and ESG performance in European firms: The Role of Firms' Bankruptcy Risk

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The purpose of this paper is to explore the relationship between CEO's education and ESG performance in European firms and further investigate whether such relationship is moderated by firms' bankruptcy risk. We empirically examine the link between CEO's education and firms' ESG performance, as well as the moderating role of firms' bankruptcy risk by using a 2024 cross-sectional sample of European firms. While prior research has examined how executive characteristics affect firm outcomes, little is known about how CEO education influences ESG performance, particularly in relation to firms' bankruptcy risk. This paper extends the literature by highlighting the moderating influence of firms' bankruptcy risk on the relationship between CEO's education and ESG performance. The findings of this paper will enable business leaders, policymakers and stakeholders to better understand how ECO's education shapes firms' ESG performance under different levels of bankruptcy risk, as well as allow stakeholders to more accurately assess how executive characteristics and financial risk influence firms' ESG performance.

Sustainability Reporting and Strategic Sustainability: Connecting Information, Management, and Decision-Making in the Nordic Context

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Sustainability reporting in the EU is currently facing challenges due to regulatory uncertainties and ongoing debates about the reporting burden on companies, as well as concerns over its potential impact on the competitiveness of European firms. Relatively little is known about the internal structures of reporting or the interplay between sustainability reporting practices and sustainability-related management and decision-making. To gain deeper insight into the internal realities of sustainability reporting, this study examines how firms facilitate the reporting practice and leverage the resulting information internally. A multiple-case study will be conducted with firms in Finland and Sweden, with interviews involving top management, departmental managers (e.g., sustainability, finance, HR), board members, and individuals responsible for collecting or using sustainability information and facilitating related activities. The study aims to capture how sustainability reporting is practiced, who is involved, and how reporting information is (or is not) connected to decision-making. The analysis will focus on organizational structures, routines, and practices that enable or hinder the role of reporting in management processes. The research question guiding this study is: How can sustainability reporting be leveraged to generate internal value by informing operations and supporting change? By incorporating both Finnish and Swedish cases, the study will offer insights into the Nordic business context within the broader EU reporting landscape, providing valuable comparative and cross-national perspectives. This paper aims to contribute to a broader understanding of sustainability reporting, not merely as a compliance exercise, but as a practice for knowledge sharing, organizational alignment, and strategic management supporting organizational change. The contribution is twofold: first, it advances the theoretical understanding of sustainability reporting as an organizational practice; second, it provides practitioners with actionable insights on how to leverage reporting to generate internal value.

Stakeholder engagement: From a growth-focused to a sufficiency-focused paradigm

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Growth-focused efforts to build economies are not following a sustainable, safe, and just path: the well-being of the planet's entire population remains unattainable as planetary boundaries continue to be exceeded. Thus, an alternative approach, sufficiency, is needed to complement and replace current efforts to build economies. Here, sufficiency refers to an organizing principle that respects the boundaries of enoughness and excess. My dissertation examines how stakeholder engagement and its activities can help understand and promote the shift from a growth-focused paradigm to a sufficiency-focused paradigm. For this research task, the dissertation first organizes stakeholder engagement research and clarifies the concept of stakeholder engagement. Second, the dissertation examines the stakeholder engagement activities in the circular economy (as part of the growth-focused paradigm) and degrowth (as part of the sufficiency-focused paradigm). To clarify the concept of stakeholder engagement and examine the stakeholder engagement activities in these two different contexts, the dissertation includes four independent studies: a systematic literature review (Kujala et al., 2022), two conceptual studies (Leinonen & Lappalainen, 2023; Leinonen et al., 2025), and an empirical study (Leinonen & Paananen, 2025). To conclude, reflections on moral stakeholder engagement activities connect the central theoretical concept of this dissertation, stakeholder engagement, to the paradigm shift from the growth-focused to the sufficiency-focused paradigm: the findings of this dissertation promote an evident need for novel and more abundant approaches to strengthening moral stakeholder engagement activities.

Sustainability leadership in the circular economy transformation

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This paper contributes to the growing body of research on sustainability leadership by examining how leadership is practiced across individual, organizational, and societal levels in the context of circular economy transformation. While most circular economy research has focused on technological and managerial solutions, this study highlights the often-overlooked role of leadership and human agency in enabling systemic change.

Conceptually, we integrate insights from three key areas. First, we examine research on circular economy transformation in organizations, which has emphasized operational changes but left leadership dynamics underexplored. Second, we explore literature on sustainability leadership, which has focused on frameworks and personal attributes but lacks clarity on how leadership is enacted. Third, we apply the lens of leadership as practice to examine leadership through social interactions and everyday actions.

Empirically, we conducted an interpretive qualitative study to identify practices that enact sustainability leadership in the circular economy transformation. The study is based on 42 in-depth interviews with sustainability leaders across sectors and continents. We analyzed what these leaders consider important in their leadership.

The findings reveal that sustainability leadership is enacted through multi-level practices. At the individual level, leaders engage in daily sustainability actions, challenge existing norms, and seek evidence for transformation. At the organizational level, they foster shared mindsets, celebrate progress, collaborate with stakeholders, and use storytelling to motivate change. At the societal level, leaders promote strategic thinking, compassion, and community-building to support sustainability transitions.

We discuss two key implications. First, sustainability leadership requires a shift from control-oriented management to values-based, practice-oriented engagement. Second, a multi-level framework is needed to develop leadership competencies for navigating complexity and fostering transformation in the circular economy transformation.

Sustainability or a Trend? How Sustainable Influencers Shape Responsible Communities

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Purpose: The growth of 'Influencer Culture' has sparked conversations about sustainability. These specialised influencers, popularly known as 'Sustainable Influencers,' create content to advocate for eco-conscious living. While they encourage responsible living, their content raises ethical questions about whether they genuinely promote sustainability as a moral duty or commodify it as a lifestyle trend. This study examines how sustainable influencers frame sustainability in their social media posts. Using commodification theory, it explores how eco-consciousness is transformed into commercial benefits and its implications for building responsible communities around sustainability.

Methodology: A qualitative content analysis of Instagram posts was conducted for three sustainable influencers (1) @zerowasteadda (2) @going.zero.waste and (3) @greengirlleah. A sample of 11–15 posts per influencer was analysed, focusing on captions, visuals, and sponsored content. We thematically coded the posts to identify recurring patterns that are used to frame sustainability on social media.

Findings: The content analysis reveals three dominant ways to portray sustainability- sustainability as advocacy, sustainability as aesthetics and sustainability as consumerism. As advocacy, influencers create educational and awareness-driven posts encouraging behavioural change and foster a sense of collective responsibility. As aesthetics, sustainability is presented as a curated lifestyle that shapes how communities perceive eco-conscious living. Under consumerism, influencers promoted products as being sustainable and eco-friendly. This can either support responsible choices among community or reduce sustainability to just another trend.

Limitations: We analysed a small set of Instagram influencers. Further studies could test these findings with a larger and more diverse sample.

Practical Implication: Findings help brands, policymakers, and consumers in understanding how sustainability is communicated through influencer content. Thus strengthening transparency in influencer campaigns.

Originality: Study uniquely applies Commodification theory in the novel context of sustainable influencers. Analysis reveals how influencers convert sustainability into commercial narratives and how it guides responsible and ethical community practices.

Choosing Green: The Divergent Roles of Cognitive and Emotional Product Involvement in Shaping Green Sacrifice

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Humans are currently consuming natural resources at a rate 1.7 times faster than the Earth's ecosystems can regenerate. This unsustainable pattern of consumption has prompted a growing demand for sustainable and environmentally friendly products that reduce resource use and promote a more viable future for coming generations. In turn, this shift in consumer priorities has led to a notable increase in climate-friendly products on the market, as more people actively seek out sustainable options in their purchasing decisions. According to a report by IEMA, these environmentally conscious consumers are not only guided by green values but are also willing to make personal sacrifices—such as opting for locally produced goods and accepting longer delivery times—in order to act in line with those values. Such sacrifices reflect a deeper form of engagement with sustainability.

Given the potential disharmony between green values and monetary sacrifices for sustainability, we investigate if consumers are willing to sacrifice a lower price tag and pay more for green alternatives to align with their environmental values. We also examine how consumers' cognitive and emotional engagement with ecologically innovative wood-based products influences their purchasing decisions. These products—such as a wood-based water bottle, t-shirt, and biodiesel—represent important sustainable innovations developed by Finnish manufacturers. Across three studies, we find that environmentally conscious consumers are willing to choose the climate-friendly option, even when it comes at a higher cost. We further show that the effect is even greater if the consumer is emotionally engaged with green products, while cognitive engagement dampens green consumers' willingness to pay more for climate friendly products. While these effects hold over time, the results suggest differences across product classes.

Building Networks for Nature-based Solutions: The UEF Living Lab

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In this presentation, the eNaBLS/EU-Horizon project's UEF Living Lab will be introduced. eNaBLS aims to tackle urgent sustainability challenges by fostering networking and collaboration to promote transdisciplinary dialogue and embed Nature-based Solutions (NBS) concepts within universities, vocational schools, the professional sphere, and society at large. Through Living Labs in seven European countries, the project advances NBS as a pathway to biodiversity preservation, climate resilience, human well-being, social equity, and green employment.

At the University of Eastern Finland (UEF) Living Lab, our goal is to create a hub where stakeholders interested in NBS can connect and collaborate. During the first year, we developed a multidisciplinary introduction course on NBS, engaged in campus events, organized hybrid meetings, and facilitated research site visits for students and staff. We have supported researchers working on NBS and students in finding thesis opportunities. Looking ahead, we aim to amplify this impact by hosting a large-scale networking event that brings together students, staff, and organizations working with NBS, complemented by smaller hybrid sessions showcasing Living Lab outcomes. Through these activities, the UEF Living Lab seeks to advance knowledge exchange, foster collaboration, and accelerate the integration of NBS into education.

Intergenerational Knowledge Sharing and Recognition of Young People in Biodiversity Conservation: Lessons from M&B Reserves in Finland and Tanzania

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Different societies worldwide have historically employed diverse approaches to share knowledge on biodiversity, on how to conserve biodiversity and on how to use natural resources sustainably. However, rapid socio-economic and environmental changes may impoverish the knowledge base of local communities required to conserve biodiversity. Today, younger generations tend to have more recent scientific knowledge on the state of biodiversity and on conservation measures while elder generations tend to have traditional and local ecological knowledge on those. Regrettably, young people interested in biodiversity conservation often face the challenge of being expected to learn from the elders, while their knowledge remains less recognised by elder generations. In this qualitative case study, we seek to understand whether and how intergenerational knowledge sharing can enable the recognition of young people and collective action inclusive to younger generations´ role in biodiversity conservation. The case studies were conducted in two UNESCO Man and Biosphere Reserves: in North Karelia, Finland, and in Amani Nature Reserve, Tanzania. We investigate the potential of intergenerational knowledge sharing in the organising of an exhibition conducted by local association Metka in Finland and of a collaborative training organized by Amani Friends of Nature (AFON) in Tanzania. Findings reveal that, different generations have different but complementary knowledge on biodiversity and competences to conserve biodiversity. Practices that enable intergenerational learning can work as platforms for different generations to debate, learn and understand each other's perspectives, expectations, and hence enable the forming of common understandings of appropriate measures to conserve biodiversity. We argue thus that intergenerational knowledge sharing can catalyze collective action for biodiversity conservation and that the complementary knowledges and competences of different generations can turn into collective capability on designing, developing and adopting new strategies towards biodiversity conservation if facilitated in ways that recognise young people´s competences.

An integrated multi-sensor remote sensing approach to characterize the trend of chlorophyll-a concentration in Lake Pyhäselkä, North Karelia, Finland

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Eutrophication is a global problem that affects fresh and coastal waters due to excessive loading of nutrients such as phosphorus and nitrogen, both of which drive algal blooms and promote the growth of other aquatic plants. The sources of nutrient loading are mainly from agriculture run-offs, industrial and municipal wastewater. In Finland, long monitoring studies of water quality parameters have indicated improvement in water quality since 1962. However, studies on the long-term trends in small and shallow water bodies are few. Thus, the main objective of this study is to investigate small and shallow water bodies and map the temporal and spatial trends in eutrophication.

In this study, we use a multi-sensor remote sensing approach to investigate and characterize chlorophyll-a trends in Lake Pyhäselkä while Lake Rokuanjärvi is a reference.

We used high-resolution Sentinel (10m) and Landsat 8 and 9 (30 m) satellite observations corresponding with the summer months of June, July and August from 2013 to 2025. Also, we used RGB and multispectral drone (3 to 4 cm resolution) images collected in 2024 and 2025. To complement the remotely sensed imagery, we used in-situ water quality (phosphorus and nitrogen) measurements from Hertta database and TARKKA Service (SYKE). For the Sentinel and Landsat, we used a pixel-wise approach to produce estimates of the Normalized Difference Chlorophyll Index (NDCI). We used the non-parametric MannKendall method to detect trends and the Sen's Slope to characterize the magnitude of change. The satellite images were processed and analyzed using Google Earth Engine while the drone images were processed using Agisoft and OpenDroneMap softwares. Additional statistical analysis were done using R-Statistical Software.

The preliminary results indicate that Lake Pyhäselkä has low chlorophyl-a values, indicating low levels of nutrients and is in general clean. However, this result is not conclusive and requires further investigation.

Real-Time Computer Vision Based Flood and Puddle Detection in Urban Areas

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Urban flooding poses a significant risk to safety and infrastructure, requiring fast and reliable detection systems for early warning. However, not all street-level water is dangerous – common puddles or minor water pooling are not dangerous. Differentiating actual flood conditions from ordinary water accumulation is essential to avoid false alarms. Street-level flood detection can be significantly enhanced using advanced real-time vision models and modern networking.

In this study, a real-time flood and puddle detection system using advanced computer vision and edge-networking technologies is presented. Based on the YOLOv8 object detection model, the system is designed to classify and localize flood and puddle instances in urban street scenes.

A 5G-connected camera system is integrated to live-stream street-level video, ensuring high-resolution, low-latency data for the model to analyse. 5G technology improves responsiveness by delivering real-time feeds from distributed urban cameras, allowing the model to detect flooding events promptly across a city.

The model was trained on a diverse dataset of 9,467 images. This dataset was compiled from the Roboflow platform, merging multiple flood and water-image datasets. This combined dataset and careful preparation (including adding non-flood background scenes) improved the model's robustness in differentiating true floods from ordinary puddles. YOLOv8 achieved high precision (~90.6%) in detecting flood scenes with minimal false positives, and solid recall, though smaller puddles were occasionally missed (water-class recall ~72.4% indicating room for improvement).

The system was successfully tested using the Savonia UAS 5G test environment and camera system, confirming its suitability for integration with existing street surveillance infrastructure. These results demonstrate that YOLOv8, when combined with 5G connectivity, offers a scalable and efficient solution for smart urban flood monitoring.

Enhancing Soil Health with Algae-Based Biofertilizers and Seagrass-Derived Amendments

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Soil degradation and nutrient depletion threaten sustainable agriculture, particularly in arid and coastal regions. This study explores an innovative soil intervention combining algae-based biofertilizers with seagrass-derived organic amendments to improve soil fertility, water retention, and microbial activity. Algae provide essential nutrients and bioactive compounds that stimulate plant growth, while seagrass residues enrich soil organic matter and enhance soil structure. By integrating these natural resources, the intervention offers a sustainable, eco-friendly alternative to chemical fertilizers, reducing environmental impact and promoting climate-resilient agriculture. The approach leverages existing knowledge and open-access data on soil properties, plant nutrition, and coastal biomass availability, demonstrating a scalable and low-cost solution adaptable to diverse agroecological conditions. This research highlights the potential of combining marine biomass with bioengineering strategies to restore soil health and increase crop productivity sustainably.

Kissamajas: Managing peak loading at wastewater treatment plants

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Sanitation360 is pioneering a circular sanitation solution that transforms human urine into safe, climate-positive fertilizer. This is directly addressing one of the most pressing challenges in global food systems: the mismanagement of nitrogen and phosphorus. By recycling these nutrients back to agriculture, we close the loop between city and farm, reduce dependency on synthetic fertilisers, and prevent eutrophication of waterways.

Our flagship innovation, the Kissamaja, is a portable unisex urinal (launched 2025) that offers an inclusive, hygienic, and circular toilet experience while capturing urine at source. The collected urine is stabilised, dried, and processed into a granular fertilizer that is easy to store, transport, and apply with existing farm equipment. This approach intercepts the 80% of nitrogen and 50% of phosphorus found in domestic wastewater. Our unique technology turns a major source of pollution into a resource that sustains food production.

Everybody's pee counts and Sanitation360 is focusing to capture the most by implementing in urban areas impacted by peak loading (when wastewater treatments struggle most). By targeting arenas and high-traffic buildings, we can rapidly scale the positive impact. In urban areas, source-separating toilets reduce nitrogen and phosphorus loads in overburdened wastewater treatment plants, freeing capacity for new buildings and limiting pollution of rivers, lakes, and coastal ecosystems.

One step aerosol synthesis of Ag doped TiO2 for photocatalytic degradation of Salicylic acid in aqueous environment

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Salicylic acid (SA) is a key component of many cosmetics products, creams, gels and transdermal patches. Its continuous discharge and accumulation in aqueous environment may disrupt metabolic processes, induce oxidative stress, and affect behavior and physiology in living species. This study deals with aerosol synthesis of 10% Ag doped TiO2 using flame spray pyrolysis and investigate its role in photocatalytic degradation of 20 mg/L SA. Surface morphology of the as produced particles shows that silver nanostructures are dispersed in the produced TiO2 particles. These silver nanostructures may induce plasmonic effects leading to enhance the photocatalytic activity of TiO2. Results show that 10% Ag doped TiO2 exhibits higher degradation efficiency compared to commercial anatase TiO2 under irradiation of λ = 365 nm for 2h. The catalyst loading and pH environment have significant impact on the photocatalytic activity of the Ag doped TiO2. Results show that 10 mg/L loading of the photocatalyst under basic conditions exhibit 57% degradation SA. The degradation mechanism of SA has also been identified and proposed.

Influence of COD and Temperature on E. coli Contamination in Kathmandu Valley Ponds: Public Health and Environmental Concerns

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Pond water in the Kathmandu Valley is a critical environmental resource, historically significant and extensively utilized for irrigation, domestic use, livestock sustenance, and the maintenance of local biodiversity and landscape aesthetics. However, escalating pollution—driven by urbanization, surface runoff, agricultural effluents, and organic waste—poses substantial threats to public health and ecological integrity. This study assessed key physicochemical parameters — temperature, pH, TSS, turbidity, iron (Fe^{2+}), nitrite (NO_2), phosphate (PO_4^{3-}), ammonia (NH_3), DO, BOD, and COD — alongside microbial indicators (total coliforms and E. coli) in 27 pond water samples collected during the 2023 monsoon season. Coliforms were present in all ponds, while E. coli was detected in 67%, exceeding the European Union's threshold for safe potable water. Additionally, all ponds surpassed WHO drinking water limits for TSS and turbidity, 67% exceeded iron thresholds, and 96% recorded BOD and COD values above USEPA limits, posing significant risks to aquatic life. Binary logistic regression revealed COD and temperature as significant predictors of E. coli contamination ($P = 0.001$ and $P = 0.023$, respectively). A three-dimensional visualization of the data reinforced this relationship, showing COD's stronger influence. The results suggest that elevated COD and higher temperatures may promote E. coli proliferation. These findings emphasize the need for enhanced wastewater management, including the regulation of sewage discharge, agricultural runoff, and organic load, to reduce COD concentrations. Adaptive measures like restoring vegetation, increasing green cover, and reducing urban heat emissions are critical to controlling temperature-related microbial risks. Seasonal monitoring is recommended for managing water quality and safeguarding public health and ecosystems.

Behavioural and Developmental Effects of Tire Rubber Leachates on the freshwater snail Physella acuta

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In freshwater ecosystems, tire wear particles (TWPs) have become a consistent part of microplastic contamination, reflecting emissions that reach between 0.5 and 5 kg per Capita per year. Furthermore, additives present in tire rubber (TR) cause negative effects in wild species at the population level, justifying research about them.

In this study, the toxicity of TR leachates (containing additives) was assessed using behavioral and developmental endpoints in the freshwater snail Physella acuta. It is an invasive species, distributed across the World because its adaptability to variable environments and high reproductive output.
We tested changes in the behavior of adults (speed, distance, exploration and meander) as well as the embryonic development in exposures to TR leachate. The leachates were prepared by shaking a 10g L-1 suspension of TR in water (2 w; 160rpm). The filtered leachate (0.22 µm membranes) was considered as 100% concentration.

After exposure of adult P. acuta to concentrations of 0, 1, 5,15 and 25% of leachates, behavior endpoints were measured before and after the addition of a predator chemical cue. In the embryo development tests, P. acuta eggs were exposed to 0, 5, 10, 25, 50 and 100%, and a dose response curve was built to calculate the EC50.

The results indicated an impairment at concentrations of 25%, first in the behavior compared to controls and second in the response to predators. The embryo toxicity test resulted in a concentration dependent success, with an EC50 of 7.9% of leachate and malformation at the 5 and 10% concentrations. In the real environment, embryos would be at risk due to the high emissions of TWPs and their additives. On the other hand, higher emissions of TWPs would be needed to cause effects on the behaviour of adult P. acuta, although we cannot rule out toxicity on the long term.

Responsibility for a changing future – Anglers' perspectives on 10 key themes related to sustainable recreational fisheries management in Sweden

Samuel Blyth[a], Patrik Rönnbäck[a], Lotte van den Heuvel[a], Emma Björvik[a]

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In the horizon scan by Holder et al. (2020) researchers and experts identified a series of 10 research themes or categories to guide the collection of new knowledge, inform policies, and support the responsible and sustainable development of recreational fisheries. Through a survey of members of Sweden's national anglers association (Sportfiskarna, a conservation oriented NGO), we quantitatively analyzed anglers' perspectives on these 10 themes in the context of Swedish recreational fisheries management. Our findings reveal the relative importance anglers place on each theme, and to whom they attribute responsibility for addressing each theme (including private fishing rights holders, the recreational fishing industry, Sportfiskarna, governmental institutions, and anglers themselves). Respondents ranked themes relating to environmental challenges and regulations as the most important. Themes relating to human dimensions, catch and release, bioeconomics, and fishing pressure were ranked as the least important. For the majority of the 10 key themes, anglers placed the greatest responsibility for addressing these themes on Sportfiskarna and various levels of government, while placing less responsibility on the anglers themselves, the recreational fishing industry, and fishing rights holders that privately manage fisheries in the majority of inland waters. The results of this study improve our understanding of resource users' perceptions of the challenges facing recreational fisheries, and their expectations regarding personal and institutional responsibilities for addressing these challenges.

Thermal refuges and habitat complexity support brown trout resilience in boreal river restoration

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Restoration strategies in boreal rivers should aim to enhance ecosystem resilience to climate change. This requires better understanding of fish habitat preferences, protection of thermal refuges, and mitigation of habitat loss.

In TRIWA LIFE-project, we examined the role of thermal refuges in boreal rivers for brown trout (Salmo trutta). The streams surveyed varied in ecological status, ranging from near-natural to restored and channelized conditions. To assess trout habitat use and availability, we employed innovative methods such as thermal infrared imaging and machine learning, complemented by electrofishing surveys. Our data resolution, namely centimeter-scale information from drones, detailed bathymetry, and precise fish location data, enabled a fine-scale understanding of habitat features influencing trout distribution.

Preliminary results indicate that trout were more abundant in stream sections characterized by higher sinuosity and the presence of groundwater. These findings offer direct insights for improving current restoration practices by emphasizing the importance of thermal refuges and geomorphological complexity.

Lessons from Lake Inari: Challenging the Sustainability of Stocking Practices

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Freshwater ecosystems are increasingly challenged by anthropogenic pressures, including hydropower regulation and fisheries, which alter the ecological and evolutionary dynamics of fish populations. Lake Inari in northern Finland provides a long-term case study of multi-species adaptive fisheries management under such pressures. For the past 50 years, a stocking programme has been implemented to compensate for losses to fisheries. While non-native species were included initially, stocking has since focused on native brown trout (Salmo trutta), Arctic charr (Salvelinus alpinus) and large sparsely-rakered whitefish (Coregonus lavaretus fera). Since 1996, an adaptive stocking process has been applied, integrating annual monitoring, fish marking, catch statistics, and stakeholder input in five-year cycles. Annual monitoring includes comprehensive catch sampling and assessment of natural reproduction. Results indicate that stocked whitefish contribute minimally to the catch, while stocked brown trout display life-history traits distinct from wild conspecifics, potentially generating adaptive mismatches if they reproduce successfully. High densities of stocked individuals may also cause transient increases in parasite prevalence and alter intra- and interspecific interactions. Furthermore, stocking may inadvertently reinforce unsustainable fishing practices by temporarily boosting catch rates without enhancing natural population resilience. Long-term monitoring highlights limitations in the capacity of stocking programmes to support local fisheries and raises concerns regarding their ecological and evolutionary sustainability. These findings underscore the importance of integrating ecological and evolutionary principles into fisheries management to ensure long-term sustainability.

Angling standard for collecting population data of the northern pike (Esox lucius) in small boreal lakes

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Knowing the relationship between catch per unit effort (CPUE) and population density is crucial for the management of recreational fisheries. We developed a predefined angling protocol for pike and applied it to compare angling CPUEs with population density in eight small boreal lakes (3.4−22.2 ha). The angling CPUE (fish hour $^{-1}$ km $^{-1}$) was statistically significantly explained by the pike density (fish ha^{-1}), whereas water temperature, use of a boat, daytime, or transect fishability had no effects. The lure type had a significant effect on CPUE (fish hour km $^{-1}$); however, the only significant difference in CPUE was between spoons and spinnerbaits. Lure colour (natural vs. fluorescent) had no effect on CPUE (fish hour $^{-1}$ km $^{-1}$), nor did lure type affect the size of the caught fish. Our results suggest that angling according to a fixed protocol can be utilised to derive density and potentially individual size metrics for fisheries management or research purposes in waters with no or little fishing pressure.

Disentangling the Drivers of Perch Growth: Environmental and Biological Controls in the Archipelago Sea

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Understanding the drivers of fish growth is crucial for predicting stock dynamics in the face of climate change and anthropogenic pressures. In complex brackish ecosystems like the Archipelago Sea, fish populations are influenced by a dynamic interplay of biotic and abiotic factors, yet their relative importance remains poorly resolved. Here, we disentangled the key drivers of somatic growth for European perch (Perca fluviatilis), a key coastal predator, in the Archipelago Sea. We used a 21-year (2003–2023) biochronological dataset derived from opercula to back-calculate annual growth increments for over 19,000 individuals. Using linear mixed-effects models, we evaluated the influence of intrinsic factors (age, sex, and maturation) alongside extrinsic drivers, including climate, productivity, predation pressure (cormorants and pikeperch), and salinity. Our analysis revealed that perch growth was governed by a complex set of interactions. Warmer summer temperatures were associated with faster growth. Predation pressure from cormorants and salinity had a significant negative impact. Counterintuitively, the abundance of a major fish predator, pikeperch, was positively correlated with perch growth, suggesting that shared favourable environmental conditions outweigh direct predation effects. Furthermore, we identified significant regime shifts towards higher growth rates beginning in 2010 and again in 2020. Methodologically, our analysis also confirmed that gillnets selectively captured faster-growing individuals compared to passive gear, underscoring the importance of accounting for sampling bias in growth studies. Our findings demonstrate that perch growth is not controlled by a single dominant driver but emerges from a delicate balance between expected environmental pressures, such as climatic forcing and abiotic stressors, and counterintuitive trophic dynamics. This highlights the necessity of adopting a holistic, ecosystem-based approach to fisheries management in dynamic coastal environments.

Spending for Salmon and Sea Trout: Examining angler expenses, perceptions, and support for fisheries management

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Recreational fisheries have the potential to support significant socio-economic values as indicated in this study of salmon and sea trout fisheries in river Mörrum, southern Sweden. A survey of anglers showed that the total expenses per salmonid caught was 2400-4900 Euro and that only 17% of caught fish was retained, resulting in total expenses per retained salmonid of 14000-28500 Euro. The local economic effects were substantial with more than 50% of the total expenses attributed to the two municipalities along the Mörrum river. The study also investigated consumer surplus and willingness-to-pay for doubling of total fish stocks and doubling of large sized fish (> 80 cm). The results on economic expenses and willingness-to-pay are analyzed and discussed in the context of anglers' support of different fisheries management, perceived stock trends, satisfaction, motivation, demographics, etc. Willingness-to-pay for increased catch rates and increased catches of large fish had positive relationships with support for regulations requiring the release of post spawn and female fish and negative relationships with ending stocking programs. These findings demonstrate opportunities to maintain the economic benefits of recreational fishing activity while identifying avenues to increase the resources available for conservation and habitat restoration.

From Waste to Resource: Unlocking the Circular Potential of EAF Slags in Sweden's Fossil-Free Steel Journey

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Approximately 8 million tons of steel slag is produced every year in Europe with more than 2 million tons solely being produced by the Swedish steel industry. Electric Arc Furnace (EAF) slags are increasingly being recognized as a valuable by-product in the steel industry, and Sweden, with its strong push toward fossil-free steel and circular economy, is well positioned to make use of them.The present investigation gives an insight on the chemical and morphological properties of an aged Electric arc furnace (EAF) slag from a steel plant in Sweden. It was also an attempt to analyze the slag for its applicability to be used as a soil remediation and concrete aggregate. ICPMS, XRD and SEM were used to study the elemental concentration and different mineral phases in the EAF Slag. Different metal concentrations especially high amounts of Ca, Fe, Mg, Si and Al can make an EAF Swedish slag a good nutrient source, a limiting reagent and can be further used as a good CO_2 sequester. These characterizations for the EAF slag can be useful in providing new perspectives for its potential use and development of future environmental investigations and regulations.

Catalytic Pressurized Pyrolysis of Plastics: A Circulatory Pathway to Graphite Precursors for Li-Ion Batteries

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Sustainable recycling of plastic waste such as polystyrene (PS) into high-quality functional carbon materials is increasingly important for advanced energy storage technologies and represents a key pathway to a circular carbon economy.
In this paper, we present the results of the systematic study of catalytic pyrolysis and subsequent graphitization of polystyrene using iron oxide catalysts under elevated pressure conditions.
Sample preparation involved homogeneous dispersion of morphology-controlled iron oxide particles in acetone, including hydrothermally synthesized nanopowders (Fe2O3) using precursors: ferric chloride and different amount of urea, and direct impregnation of polymer matrices with iron salts (Fe(NO3)3*9H2O, FeCl3*6H2O). Pyrolysis was carried out in a stainless-steel autoclave at a heating rate of 1°C/min, an initial nitrogen pressure of 20 bar at 300 °C, and a final temperature of 600 °C with 2h holding. The amount of iron after pyrolysis was monitored by thermogravimetric analysis. The condensed liquid fraction was selectively analyzed on polycyclic aromatic hydrocarbons (PAHs). The solid precursors were inductively heated at 2500 °C for graphitization.
The structural and morphological features of the obtained graphite precursors were studied using transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD) and Raman spectroscopy. XRD and Raman analyses showed that amount of amorphous carbon in the graphite strongly depends on the morphology of iron catalysts. Electrochemical test showed that the obtained graphite as anode materials has relatively high coulombic efficiency and stable cyclability.
Overall, this study establishes a reproducible methodology for the conversion of PS to graphite. The results highlight the critical role of iron oxide catalysts in the formation of graphite. The proposed polystyrene recycling schemes to graphite production technology shows the practical potential of this approach for the sustainable production of electrode materials for Li-Ion batteries and possibility of integrating waste-derived feedstocks into modern energy storage systems.

Mining for Resilience: Exploring the role of artisanal and small-scale mining in climate change adaptation in rural Malawi

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Artisanal and small-scale mining (ASM) has become one of the most important rural non-farm livelihood activities in sub-Saharan Africa. This thesis, based on four years of research in Malawi, explores the role of ASM in climate change adaptation and resilience building among vulnerable rural households. It is among the first systematic studies to focus on ASM as a potential adaptation strategy.

The research sought to answer the broad question: What role does ASM play in climate change adaptation and resilience building in vulnerable rural households? Three objectives guided the study: (i) to examine how ASM supports adaptation and resilience, (ii) to analyse household-level dynamics, including roles of individual family members, and (iii) to assess Malawi's capacity to formalise ASM from both livelihood and climate adaptation perspectives.

A largely qualitative approach was used, complemented by thematic and content analyses. Primary data came from semi-structured interviews with 403 mining households across Malawi, 17 focus group discussions, five key informants, and field observations. Secondary data from policies, strategies, and legislation enriched the analysis.

Findings reveal widespread reliance on ASM as a coping and adaptive strategy in the face of climate shocks. ASM was shown to complement farming, with shared labour and income sustaining households during difficult periods. Household-level dynamics highlighted distinct contributions by women, men, youth, and the elderly, underscoring the importance of targeting individuals as well as communities in resilience programming.

Despite ASM's contribution, challenges of environmental degradation, weak market systems, and inadequate policy implementation persist. While Malawi's policies recognize ASM, formalisation remains largely rhetorical. The thesis concludes that stronger policy recognition, practical implementation, and support for responsible ASM are crucial for harnessing its potential in climate change adaptation.

This study provides novel evidence on the ASM–climate nexus and lays a foundation for further research and responsive policy in Malawi and beyond.

Untargeted profiling of organic valuables from industrial side-streams and paludicultured crops using UHPLC-orbitrap-MS and GC-MS

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The increasing demand for sustainable bio-based resources has led to a growing interest in utilizing waste biomass and paludicultured crops as sources of valuable plant metabolites. Industrial side streams commonly discarded as processing waste, represent a rich yet overlooked reservoir of bioactive compounds. In the context of a circular economy, this study aims to valorize waste biomass, such as cabbage stems by recovering high-value organic constituents through untargeted chemical profiling. We employed three extraction methods: Accelerated Solvent Extraction (ASE), Ultrasonic probe Solvent Extraction (USE), and Soxhlet Extraction. Four pure solvents of differing polarities (water, methanol, hexane, and acetone) were used to maximize compound diversity. Extracts were analyzed using UHPLC-Orbitrap-MS and GC-MS, enabling comprehensive detection of both polar and volatile metabolites.

Data processing and compound annotation were conducted using Thermoscientific Compound Discoverer and Agilent Unknowns Analysis, resulting in the identification of over 240 compounds, including sugars and sugar derivatives, amino acids and their derivatives, phenolic and aromatic compounds, and other bioactives of nutraceutical, pharmaceutical, or industrial value. This analytical approach reveals the biochemical richness of cabbage stem biomass and underscores its potential in biorefinery applications. The findings contribute to sustainable waste valorization strategies and exemplify how circular economy principles can be applied to convert vegetable processing waste into valuable biochemical resources.

Sustainable ionic luminophores of group 15 for optronics

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The advancement of chemical strategies for fine-tuning accessible and sustainable ionic molecular light emitters follows the principles of atom–photon economy, emphasizing ecological responsibility and long-term sustainability. Our approach prioritizes the design of luminophores with optimized energy utilization, offering a pathway toward efficient and environmentally conscious applications in optoelectronics.

Within the atom–photon economy framework, molecules based on group 15 elements integrate synthetic ecological assessment with atomic and photonic efficiency, thereby maximizing light energy conversion while minimizing material waste and energy losses. This strategy directly addresses critical challenges in photonics, particularly in the development of energy-efficient lighting technologies and their applications in scintillation, OLEDs, and sensing.

Our efforts extend beyond the creation of visually dynamic, high-performance molecules; they also contribute to reducing power consumption and fostering the advancement of eco-friendly photonic technologies. The introduction of energy-efficient synthetic methodologies, especially in the molecular design of ionic luminophores, represents a transformative step toward sustainable technological progress. By adhering to the atom–photon economy principle, maximizing photon output per atomic unit of an emitter, next-generation light-emitting ionic materials align with clean-technology goals and contribute to mitigating global energy consumption challenges.

To support scintillation applications, we explore key categories of eco-designed ionic luminophores, including phosphorescent ionic pairs derived from pyridinium and phosphonium cores. These ionic compounds are synthesized through nearly quantitative reactions, predominantly via one-step cyclization of phosphines or methylation of pyridines, phospholanes, and imidazoles in environmentally benign solvents. As precursors, naturally derived molecules such as vitamers B3 and B6 are employed, ensuring minimal waste generation and approaching near-zero environmental impact.

This efficient and sustainable strategy establishes a new class of eco-friendly luminophores and reinforces the atom–photon economy as a cornerstone concept for the development of next-generation sustainable photonic materials.

Enhanced Effective Thermal Conductivity for CO2 Adsorption by Building Carbon/Zeolite Composites

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Thermal swing adsorption (TSA) is a technology that allows to capture CO_2 in relative low concentrations and treat relatively large volumes of flue gas due to simple operation under near-atmospheric pressure, the ability to utilize low-grade industrial waste heat for regeneration, and the potential for achieving high CO_2 purity. However, TSA also faces challenges, particularly the long heating and cooling durations in traditional adsorption columns, which are required for each adsorption/desorption cycle, and this can lead to higher energy consumption and reduced system efficiency. Despite extensive studies on modifying or synthesizing new types of zeolites to improve the adsorption performance of zeolites for CO_2 capture, limited attention has been given to enhancing their thermal conductivity—an equally critical property of adsorbent for practical application. In thermal swing adsorption systems for commonly used granular bed adsorber, the heat transfer happened between fluid to the wall, and wall to the granular beds. For an existing column, the heat transfer between heating fluid and the wall remains unchangeable. Enhancing the adsorbent's thermal conductivity helps achieve a more uniform temperature distribution inside the bed.

In the present work, Zeolite Y was combined with two types of carbon-based thermal conductive enhancers, to form composite sorbent materials. These composites aim to address the inherent thermal limitations of pure zeolites by improving heat transfer within the adsorption bed, thereby reducing the time required for heating and cooling cycles This study explores the potential of thermal enhanced zeolite-based materials in TSA processes, and evaluates their thermal conductivity, structural properties, and CO_2 adsorption–desorption performance to support their suitability for practical carbon capture applications.

Zeolite NaX and NaA granules by high-shear wet granulation as adsorbents for CO_2 capture

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In this study, zeolite NaX and NaA granules were produced by high-shear wet granulation using polyvinyl alcohol (PVA) as an organic binder in different concentrations: 1%, 5%, and 10%. The appropriate parameters for obtaining rounded granules with a uniform granulation mixture were an impeller speed of 350 rpm and a chopper speed of 1500 rpm and 1750 rpm for zeolite NaX and NaA, respectively. The sizes of the granules obtained ranged from 1 to 10 mm. The morphology, compressive strength, and size distribution of the granules were characterized by scanning electron microscopy (SEM), compression test, and sieving according to ASTM standards. The study found that higher PVA concentrations yielded mechanically stronger granules with improved uniformity. In addition, CO_2 capture was performed on the NaX and NaA zeolite granules at different pressures of 1, 2, and 4 bar for 4 cycles in dynamic conditions, confirming their capability for repeated CO_2 adsorption cycles.

Powder and pellet form 13X zeolite adsorbent in a temperature swing CO_2 adsorption – a wide temperature range study

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The increasing climate burden compels us to develop new methods for reducing atmospheric CO_2 levels. It is no longer sufficient to merely decrease fossil fuel usage — we must also capture the CO_2 that is already being emitted. In BIOCCUS project, our goal is to capture biogenic CO_2 from biomass combustion exhaust using the TSA (Temperature Swing Adsorption) method and utilize it to produce bioplastics and biofuels. Choosing the right carbon capture material is crucial for the success of the process. We studied the CO_2 adsorption performance of commercial 13X zeolite in both pellet and powder forms over a temperature range of 5–110 °C, aiming to assess their suitability for TSA processes. CO_2 adsorption capacities were measured using a breakthrough method, while CO_2 temperature-programmed desorption was used to examine ratio of physisorbed and chemisorbed CO_2. Textural characterization of 13X zeolite forms were carried out by Brunauer-Emmett-Teller surface area analysis and powder X-ray diffraction. Results indicate that the powder form exhibits higher CO_2 uptake due to greater surface area and purely microporous structure, whereas the pellet form, although easier to handle, demonstrates lower capacity partly due to the presence of meso- and macropores introduced during pelleting. Chemisorption of CO_2 was more significant at lower temperatures and more prominent in the pellet form. These findings highlight the influence of physical form of 13X zeolite. Operating temperature on adsorption efficiency, with implications for TSA system optimization, particularly in cold climates where low ambient temperatures can enhance CO_2 capture without additional cooling energy.

Cost-Effective Ultramicroporous MOFs for Energy-Efficient CO_2 Capture at Low Partial Pressures

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Metal-Organic Frameworks (MOFs) have emerged as leading solid sorbents for selective CO_2 capture, particularly at low concentrations. However, synthesizing MOFs using inexpensive, readily available precursors that meet key benchmarks for capacity, selectivity, and stability remains a challenge. In this study, we introduce two ultramicroporous MOFs, IISERP-MOF28 and IISERP-MOF36, which demonstrate outstanding CO_2/N_2 selectivity, rapid CO_2 uptake at low partial pressures, and excellent stability in the presence of acids, bases, and humidity—critical attributes for CO_2 capture at low concentrations. These MOFs feature scalable synthesis, low regeneration energy requirements, and show promise for capturing CO_2 at low concentrations, making them strong candidates for applications in Natural Gas Combined Cycle (NGCC), Post Combustion Process and Direct Air Capture (DAC).

Planning for cool cities: The intersection of urban greening, planning standards and heat risk reduction

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Global cities are increasingly experiencing the urban heat island (UHI) effect, a pervasive outcome of rapid urbanization and climate change that threatens urban sustainability and livability, particularly in tropical regions such as Lagos, Nigeria. Hence, this study investigates pathways for creating a cooler urban environment in Lagos by positioning urban greening as a central response to rising heat risks. Using a mixed approach combining heat risk mapping with expert interviews, the study provides spatial and institutional insights into urban heat challenges. The heat risk maps highlight high vulnerability zones and priority areas where urban greening interventions are needed. At the same time, the expert interview further reveals key factors contributing to the urban heat island in Lagos State. These factors include socio-economic pressures, poor enforcement of planning laws, weak adherence to planning regulations, weak administrative structures, inadequate maintenance of existing green infrastructure, prioritization of financial gain over environmental sustainability, and persistent political interference in the Planning process. The findings suggested that encouraging household-led greening, support systems, and improvement of enforcement instruments could provide an effective pathway toward achieving cooler cities. The study concludes that household-led greening, though often overlooked, can complement large-scale efforts, helping Lagos and other rapidly growing cities build resilience to climate risks while promoting more sustainable urban development.

Investigation the circular business innovation transformation in Pakistan's textile enterprises

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Over-exploitation of resources and the burden on natural systems have provoked worldwide concerns about the potential resource and supply risks in the future. Conversely, contextual empirical research on the Circular Economy (CE) in the emerging economy of Pakistan is still in its infancy. Of particular interest in this regard is that the textile industry contributes 61% to the country's total exports. However, the relevant stakeholders have so far only explored the CE potential to a marginal extent. This knowledge gap has been the primary motivation for the present study, which aims to explore the diffusion of Circular Business Innovations (CBI) among textile-producing enterprises. The research aims to explore the dominant categories of CBI among the sample. The study employed qualitative analysis and descriptive statistics to support a multi-case study approach through key informant interviews to get an insight into 26 large textile-producing industries. Findings reveal that i) 66% of total CBI cases indicate open innovations, while the remaining are closed innovations, and ii) only 33% of current innovations pertain to product innovation, while others refer to process innovation and recycling. However, the current landscape presents an opportunity to value network stakeholders in devising actionable collaborations for the scalability and longevity of these initiatives.

Food waste of young family in urban area (a case study in Indonesia)

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By 2050, the global population is projected to exceed 10 billion, intensifying food demand and straining limited resources. One of the major challenges to food security and climate change is food waste, with households identified as the dominant source. In Indonesia, household food waste reaches 20.93 million tons annually. This study explores the relationship between socio-demographics, urbanization, food consumption management, and sustainable household food waste management among young families. Data were collected from 350 households in Bogor City and Bogor Regency, Indonesia, between July and October 2024 through face-to-face interviews and analyzed using SEM-PLS. Results show that 8 out of 12 tested hypotheses are significant. Key factors influencing sustainable household food waste management include the presence of children, financial awareness, competency and culinary skills, material and infrastructure availability, lifestyle, online grocery shopping, religiosity, and food consumption management.

Air pollution and Alzheimer's disease: Enhancing elderly care with assistive solutions

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Alzheimer's disease (AD) is a growing global health crisis affecting over 55 million people, with numbers projected to double by 2050. It is a major neurodegenerative disorder impacting the ageing population globally. In India alone, the prevalence of Alzheimer's and related dementias is expected to rise steeply, with the rise in air pollution, nuclear family structures, and limited institutional elderly care infrastructure posing a significant risk to vulnerable seniors.

Recent studies highlight a significant connection between air pollution and the acceleration of AD's onset and progression. Long-term exposure to air pollutants, particularly particulate matter (PM2.5) and nitrogen dioxide (NO2), has been associated with increased dementia risk due to mechanisms such as neuroinflammation and oxidative stress. Pollutants penetrate the respiratory system and can reach the brain through the bloodstream or olfactory pathways, with traffic-related pollutants like nitric oxide (NO) and carbon monoxide (CO) further elevating risks. Research demonstrates widespread correlations between dementia prevalence and air pollution across various demographics.

Several contributing factors exacerbate this risk, particularly during vulnerable life stages, including genetic predisposition in individuals with the APOEε4 gene and socioeconomic factors that lead to higher pollution exposure in disadvantaged neighbourhoods. Lifestyle choices, such as poor sleep and inactivity, can also intensify cognitive decline linked to pollution. Strategies promoting physical activity and addressing air quality are critical for public health and mitigating the growing dementia crisis.

The burden of neurodegenerative disorders is amplified by societal stigma, limited caregiver awareness, and inequitable access to supportive technologies. Against this backdrop, ViniBrawn Healthcare Solutions—a faculty-led social venture incubated within BML Munjal University—aims to democratize access to dignified dementia care through empathetic, technology-driven interventions. This paper explores ViniBrawn's strategic approach in positioning its flagship product, AlzoWatch and AlzoVision, as both a healthcare innovation and a scalable social enterprise that supports inclusive well-being.

How do plastic packaging taxes and regulations foster circularity in the food packaging industry? A policy mix perspective

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Plastic packaging, rooted in a linear economic model, has become central in sustainability debates, prompting European and national policymakers to accelerate circularity through targeted regulations. This paper examines how key policies, perceived as most influential by stakeholders in the food packaging industry, shape circularity-related decisions within the European–national policy mix. It aims to identify which policies stakeholders – particularly plastic packaging converters – perceive as most influential in shaping circularity-related decisions; and analyze these policies through the lens of policy mix theory, which examines how different policies and underlying instruments interact, reinforce, or hinder transitions. Drawing on qualitative interviews with food packaging stakeholders in Spain and the United Kingdom, the study reveals a governance pattern where command-and-control regulation dominates at the European level, while market-based instruments prevail nationally. Central European policies include the Single-Use Plastics Directive, the Regulation on recycled plastics in food-contact applications, the Packaging and Packaging Waste Regulation, and Extended Producer Responsibility schemes. Nationally, Spain's and the UK's Plastic Packaging Taxes, alongside upcoming reforms in the UK such as Extended Producer Responsibility, Deposit Return Scheme, and Simpler Recycling initiative, are pivotal. Despite Brexit, the UK remains aligned with European circularity goals, though fragmented governance complicates implementation. Stakeholders identified regulatory drivers such as regulatory clarity and business demand-pull incentives, as well as barriers including limited tax scope, weak enforcement, and insufficient support for upstream innovation and reuse. The analysis highlights a policy mix characterized by strong consistency, growing coherence, politically contingent credibility, and low comprehensiveness, as the policy mix remains biased toward recycling, constraining its transformative potential. This paper contributes to policy mix theory by applying it to packaging circularity, offering empirical insights - deepening our understanding of how policies are perceived and enacted in practice - and outlining implications for designing coherent, credible, and innovation-friendly policy frameworks.

How consumers experience sustainable packaging: From dimensions to tensions

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As the climate crisis keeps worsening, consumers increasingly prefer sustainably produced goods. Emerging research suggests that one critical factor affecting such choices is consumer experience, that can be studied through its five dimensions: sensory, cognitive, affective, social, and behavioral. In addition to experience, consumers' green identities influence their actions towards sustainability. The packaging business is transforming especially strongly according to consumer preferences, because consumers choose to buy products largely based on their packaging. Thus, in this study, we explore how consumers experience sustainable packaging by focusing on 1) consumer identity, 2) customer experience, and 3) sustainable packaging. We examine wood fiber-based flexible packaging, that can be used to replace a variety of plastic packaging. To examine consumers' global experiences on sustainable packaging, 23 young consumers are interviewed. According to our findings, consumers experience sustainable packaging in relation to their own identity, as well as packaging attributes. The cluster analysis of consumer identities compiles three distinct patterns of consumer identities and experiences, that lead to varying sustainability actions. The findings show that for consumers with a strong sustainability identity, the cognitive experience dimension is highlighted, and they tend to choose more sustainable alternatives. With consumers that show a smaller significance of sustainability in their identities, the experience tends to be more diverse spanning different dimensions, and the choices are more split between sustainable and non-sustainable alternatives. The differences in the patterns also debunk some misconceptions in consumer and packaging literature. This research produces academic contributions to two research streams: by 1) broadening existing literature on customer experience with connections to sustainability and consumer research, and 2) extending the literature on sustainable consumption and packaging by incorporating a customer experience perspective and offering new insights that challenge prevailing assumptions in literature.

Strategic moves in climate-oriented shareholder activism: A decade of engagement with U.S. oil and gas firms (2013–2022)

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Climate change poses an unprecedented threat to sustainable human progress. The Paris Agreement called the international community for immediate action to avoid potentially catastrophic outcomes of climate change by keeping the atmospheric temperature well below 2°C on a global scale above the pre-industrial level. This ambitious goal can only be achieved if the carbon-intensive industries commit themselves to transitioning toward a low-carbon economy. Among these sectors, the oil and gas industry—comprising more than half of the global energy mix—stands out for its major contribution to the climate crisis.

Environmentally conscious investors enter the scene here as prominent stakeholders who can hold such firms accountable for climate action. Over the last few years, responsible shareholders have formed alliances in an increasing manner to consolidate their position over the petroleum industry. They filed resolutions with the support of such partnerships and raised their unified voice on the green transition. The way in which these investors exert their power is expected to play a major role in the Paris alignment of extractive sectors.

This study employs a qualitative content analysis approach in order to examine this under-researched yet impactful form of activism. Focusing on climate-related proposals directed at major U.S. oil and gas companies between 2013 and 2022, it seeks to illuminate how climate-conscious shareholder groups engage with this high-impact sector. Specifically, the paper aims to (1) analyze the strategic moves employed by climate activist shareholders, (2) assess their effectiveness in driving corporate engagement, and (3) trace the evolving trends in climate-oriented shareholder resolutions over the past decade.

Libidinal desire within stakeholder engagement: The case of the Sokli mine development in Savukoski, Finland

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The mining sector, in the Nordics as well as globally, has begun to assert itself as a contributor in fighting climate change through providing the material basis for de-carbonization and digitalization. In accordance with this, the development of the industry in Finland is framed through responsibility, sustainability, and transparency. This paper will present preliminary results from ethnographic research in the Savukoski region during 2025. Based on 32 interviews with locals, company executives and employees, members of the Kemin-Sompio reindeer herding association and representatives of local environmental associations, the research analyzes the stakeholder process of the Sokli Oy mining company, and local attitudes to it, through the lens of the libidinal economy. Libidinal economists situate desire at the center of the economic system. The theory is useful in the analysis of the contemporary mining industry, often shaped by unconscious, even irrational desires. Since the 1960's, the Sokli carbonatite massif has been subject to decades of drilling, speculation, and expectation. In 2020, the deposit was aquired by the Finnish Minerals Group. Since then, the company has sought to garner social acceptance for the rapidly evolving project through various techniques of stakeholder engagement. Due the long history of the project, the stakeholder process is not simple. Albeit being heralded by some as the savior of the municipality, opposition to the mine is also strong, even described as "generational". The paper argues that approaches to stakeholder engagement through libidinal economic theory are under-developed, and seeks to provide a novel lens through which to analyze mine development in the context of the seeking technological solutions to the climate crisis, the dwindling possibilities for traditional livelihoods, and the protection of wilderness areas from techno-industrial development in Northernmost Europe.

Grassroots innovation in Mauritius: Understanding Limitations and Opportunities for Transformative Impact

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Grassroots innovation initiatives play a crucial role in supporting sustainability transitions in island communities, driving fundamental changes towards more resilient and environmentally sustainable pathways. However, they are often confronted with challenges. This study seeks to understand the barriers and opportunities for accelerating grassroots innovations in Mauritius based on the experiences and perceptions of community members engaged in various grassroots initiatives. The study employs a qualitative approach, using semi-structured interviews. The findings reveal that barriers such as socio-cultural mindsets, credibility issues, funding constraints, political and institutional barriers, and policy implementation gaps hinder the acceleration of grassroots innovations in Mauritius. In response, the study suggests that policy reform, localised production, innovative financing mechanisms, experimentation, community empowerment, socio-cultural shifts, private sector partnerships, sustainable blue ocean economy, multistakeholder and regional collaboration may be instrumental in overcoming barriers and enabling grassroots sustainability innovations to thrive and contribute to broader sustainability transitions in Mauritius. The study provides pathways for accelerating grassroots innovations, shaping a sustainable and resilient future from the bottom up and offers valuable insights for grassroots change agents, researchers and policymakers alike.

Regionally divergent drivers behind transgressions of the freshwater change planetary boundary

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Human-driven freshwater change contributes to elevated Earth system risks. Here, we advance the understanding of drivers behind the transgression of the planetary boundary for freshwater change (PB-FW), based on historical (1901–2019) streamflow (blue water) and soil moisture (green water) simulations from a large ensemble of global hydrological models. Since the former estimate ending in 2005, PB-FW transgression has increased across its blue and green water components. Decomposition of climate-related forcing and direct human forcing (encompassing land and water use changes) shows that climate has increasingly become the dominant global influence on dry and wet streamflow and soil moisture deviations from preindustrial-like conditions. Moreover, direct human forcings intensify particularly dry deviations in regions with compounding pressures on ecosystems. Our approach characterises the main drivers of blue and green water changes in regional hotspots, improving the utility of the PB-FW for guiding mitigation and adaptation strategies in response to freshwater change.

A preprint of the study is available at: https://doi.org/10.31223/X54X7M

First positive steps: Emerging biodiversity handprints in the Finnish tourism sector

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The tourism industry has become increasingly aware of the global biodiversity crisis and its impact on the sector. In response, efforts are being made to reduce tourism's negative ecological footprint while enhancing its positive handprint (UNWTO, 2024; WTTC, 2023). Handprints refer to voluntary actions aimed at improving environmental conditions (Guillaume et al., 2020). This study examines the types, drivers, and effectiveness of biodiversity handprints implemented by tourism businesses in Finland.

The study's empirical data consists of interviews with 35 purposively selected forerunner micro-level tourism businesses, primarily operating in two Finnish biosphere areas. These interviews are supplemented with data on biodiversity actions undertaken by all Sustainable Travel Finland -certified companies between 2022 and 2024 (N=279–494 per year). The study categorizes different types of biodiversity handprints based on an adapted classification from Norris (2015) and Guillaume et al. (2020). The effectiveness of these actions is assessed in relation to negative environmental footprints to estimate company-level contributions to nature-positive tourism (UNWTO, 2024). Additionally, motivations behind biodiversity handprinting, as well as perceived agency and self-efficacy among tourism actors, are analyzed.

The majority of identified biodiversity handprints consisted of small-scale, direct actions carried out within the companies' own premises or operations. These efforts represent an initial step toward biodiversity-respectful tourism. However, their scale remains insufficient to counterbalance the broad range of negative environmental impacts caused by tourism activities, infrastructure and logistics. Consequently, the nature-positivity of the studied companies was relative; they are making improvements, but these are still small compared to the overall footprints. The key drivers for biodiversity handprinting were primarily intrinsic, stemming from the personal values of tourism operators rather than external pressures such as regulatory requirements or customer demands. Handprinting provided a sense of agency and self-efficacy, empowerment, but this was perceived limited; broader external threats remained beyond the sphere of influence.

Water struggles: Water ethnography of a coastal village in southwestern Bangladesh

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People's perceptions of water and their responses to water issues are not homogeneous. Global coastal zones have enormous potential in food, nutritional, and energy sources and in mitigating climate change. Challenges in coastal areas are also high compared to other regions; cyclones, storm surges, salinity intrusion, coastal embankments, and sluice gates. Forty percent of the world population lives in coastal zones, and the freshwater problems are acute and high in the global south and coastal zones. Due to socioecological and natural settings, some regions, occupations, and socioeconomic groups are more vulnerable than others. Water demand is incremental, total freshwater is static, and in decline. Water demands are contextual and related to a sociocultural group. There are unique but different water practices that exist in society. Coastal water challenge exacerbates with climate change, local and national development plans, polices, and politics. Rainwater harvesting and conservation are some of the oldest water-related adaptation practices in the Bangladesh coastal zone, and there are two different forms of this: individual and community level.
Every household in the village has a pond or water ditch, and there are also common ponds for drinking freshwater. Canals are controlled, and the village and agricultural land are wet irregularly. The natural water systems and community-based water practices were repeatedly challenged due to outside interventions and hard structure and techno-centric adaptations, e.g., the Bangladesh coastal embankments project, introduction of plastic water tanks. To understand water struggles, everyday drinking, household consumption, fishing, and agricultural water use are observed, and informal discussions are organized with different cultural, socioeconomic, and age groups. It also reveals that to understand the water struggles requires a multipole lens. Through the hydrosocial, feminist political ecology, and slow violence lens, we argue that the water struggles are contextual, not gender neutral, and invisibly persist in society.

Optimizing Sustainable Tourism Through Trip Duration Analysis: Representative Study of International Tourists to Finland

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Background: As tourism's environmental impact intensifies, understanding the relationship between trip duration, economic benefits, and carbon emissions becomes crucial for developing sustainable tourism strategies. This study examines how trip length affects the economic-environmental efficiency of tourism in Finland.
Methods: Using Matkailijamittari open data set with representative survey data from international tourists to Finland, we analyzed weighted 9.9 million annual tourism trips to Finland across seven duration categories (1 day to 61+ days). We calculated economic-environmental ratios by comparing total spending (€7.9 billion annually) to carbon emissions (6.57 megatonnes CO_2) across different trip lengths, examining both total and daily efficiency metrics.
Results: Trip duration significantly influences tourism sustainability patterns. Short stays (1-3 days) represent 32.3% of trips but only 12.2% of total spending, with poor economic-environmental ratios (0.57-0.83). Medium stays (4-14 days) dominate tourism volume (55.7% of trips, 59.1% of spending) with near-average sustainability ratios (0.93-1.06). Long stays (15+ days) demonstrate superior sustainability efficiency (1.10-1.26 ratios) despite comprising only 12.0% of trips. Daily spending exhibits a strong inverse relationship with trip duration, peaking at €148/day for 2-3 day visits and declining to €26/day for ultra-long stays (61+ days).
Conclusions: Our findings reveal a "sustainability paradox" in tourism duration: while longer stays achieve better overall economic-environmental ratios, shorter stays generate higher daily economic impact. The optimal balance occurs in 8-14 day visits, offering substantial total spending (€1,105 average) with reasonable daily rates (€115/day) and moderate environmental impact. These insights suggest targeted strategies: enhancing short-stay value without extending emissions, promoting medium-length optimal stays, and developing long-stay programs for maximum sustainability. This duration-based approach provides a novel framework for destinations seeking to balance economic objectives with environmental responsibility.

POSTER PRESENTATIONS

Challenges to the nutrient recycling business and solutions

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Organic waste is rich in plant nutrients, making its recycling important for sustainable waste and nutrient management. Several recycling techniques have been developed, with composting being the most widely used. Composting is a natural, easy, and traditional process, and its end products can improve soil quality. However, many compost-producing companies are facing economic challenges. The limited market size for compost is primarily due to: (1) risk of contamination, (2) bulkiness for transportation, (3) low nutrient content, (4) slow nutrient release, (5) high application rate, and (6) possible need for supplementary mineral fertiliser. Therefore, new techniques are needed to address these issues.

Nutrient recycling technologies, such as Ostara, NPHarvest, and Ash2Phos, have been developed to recover and produce nitrogen (N) and phosphorus (P) based fertilizer from waste. These products can be only 2.5 to 5% of the original waste volume. Implementation of these techniques locally can produce a low-carbon footprint mineral fertilizer since it reduces transportation distance and GHG emissions. However, only a few of these technologies have reached commercial scale, likely due to: (1) high operational costs, (2) availability of cheaper waste disposal options, (3) low fertilizer value of end products, and (4) potential contamination risk.

Most nutrient recycling techniques recover N as ammonium sulfate, which is a well-known N-based mineral fertilizer. In contrast, P recovery is often studied to get struvite, calcium phosphate, or vivianite, which are not commonly used by farmers and are not marketed by leading fertilizer companies like Yara. Therefore, to improve adoption and market viability, nutrient recycling techniques should aim to: (1) produce water-soluble P compounds similar to conventional mineral fertilizers, (2) integrate their products into the existing fertilizer supply chain, and (3) produce raw materials suitable for larger fertilizer companies.

Towards Social Sustainability: Addressing Deficiencies in the Coffee Supply Chain

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This study investigates critical social sustainability deficiencies within the global coffee supply chain, focusing on poverty-related problems, gender inequality, and systemic workplace inequalities. Given coffee's importance in global trade and socio-economic development, the paper identifies key root causes of these social challenges, including economic vulnerability, cultural constraints, and structural inequalities. The study evaluates practical solutions across multiple levels: international regulations, governmental policies, corporate strategies, and consumer-driven actions. It emphasizes the role of supply chain transparency, certifications, and technological innovations in promoting ethical practices. The findings highlight that while significant progress has been made, structural barriers and power imbalances persist, requiring integrated and collaborative efforts for long-term social sustainability in the coffee sector.

Tree bark valorisation for bioactive extracts against wood-decaying fungi and viruses

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Tree bark is known as a rich source of extractives with diverse chemical structures and bioactivities. It is still considered as a low-value by-product of the forest industry and hence underutilized in terms of its biorefining potential. Promoting its valorisation could contribute significantly to sustainable resource utilization and the development of bio-based alternatives to fossil derived products. This work demonstrates how bark valorisation can support a sustainable bioeconomy by enabling the extraction of bioactive compounds through various biorefinery approaches, including conventional methods such as maceration and thermochemical processes like pyrolysis. Several tests were performed to chemically characterize the extracts, such as, FT ICR MS and GC MS. Antifungal tests and mini-block tests in vitro were performed to assess the potential of bark extracts as wood preservatives. To determine the antiviral properties of the extracts, viruses were pre-incubated with them, and the infection was followed by a cytopathic effect (CPE) inhibition assay. All extracts exhibit a characteristic chemical fingerprint, highlighted by the presence of phenolics. terpenoids, and resin acids. The results revealed that Silver birch (Betula pendula) pyrolysis liquid exhibited strong antifungal activity against wood decay fungi, while pyrolysis liquids of European aspen (Populus tremula) did not inhibit the decay. Silver birch bark extracts completely stopped viral infection, whereas European aspen extracts showed not antiviral effect. The results varied depending on bark species and extraction method, indicating that these factors play a crucial role and should be further investigated. Overall, this work highlights the potential of bark valorisation for the obtention of high value functional chemicals that can be used to stop fungal and viral infections.

Morphology-Controlled Iron Sulfate Catalysts for Biomass Graphitization

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The increasing global demand for high-performance energy storage has intensified research on sustainable alternatives to conventional graphite anodes in lithium-ion batteries. Biomass-derived carbons have emerged as attractive candidates due to their abundance, renewability, and potential for tunable nanostructures. However, achieving a high degree of graphitization in biomass carbon typically requires extreme processing conditions, limiting their large-scale applicability. Catalytic graphitization offers a promising pathway to overcome these limitations by lowering energy requirements and enabling controlled structural development. In this context, transition metal-based catalysts, particularly iron compounds, have demonstrated strong potential in promoting the transformation of disordered carbon into graphitic structures.

In this study, iron sulfate–based catalysts were designed for biomass graphitization. Two catalyst types were synthesized using a spray dryer equipped with an ultrasonic nozzle: pure iron sulfate and iron sulfate–urea composites, both obtained as spherical particles in the micrometer range. The catalysts were subsequently calcined to form iron oxide phases and characterized by scanning electron microscopy (SEM) and thermogravimetric analysis (TGA), which confirmed their uniform morphology and thermal behavior. These catalysts were then applied in biomass pyrolysis and graphitization. Post-treatment analyses revealed that catalyst morphology strongly influenced carbon structure: SEM of the graphitized products showed distinct morphologies depending on catalyst composition, while Raman spectroscopy confirmed differences in graphitization degree and structural ordering.

The outcomes will provide new insights into the design of biomass-derived carbon materials and efficient catalytic strategies for graphitization. Ultimately, this work supports the development of sustainable electrode materials for next-generation energy storage systems.

Bio-based phenols utilized in 3D printed polymer composites and coatings

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3D printing is a modern fabrication technique utilizing different classes of materials (polymers, metals, ceramics and composites) for a wide range of industrial and household applications. In addition to prototyping or research purposes, it allows producing complex designs, lightweight porous structures and even creating practical items for household or personal use in various sizes and with minimal material waste. Furthermore, new sustainable bio-based materials can be utilized in 3D printing, and they are actively developed to replace conventional petroleum-based 3D printing chemicals at least partly.

Thermochemical methods such as slow pyrolysis and hydrothermal liquefaction can be utilized to convert biomass to solid biochar/hydrochar and liquid distillates. These products can be utilized for example in coatings and composites. The raw distillates readily available from thermochemical process can be further fractioned and purified to utilize their antimicrobial, antifungal and other functional properties in adhesives, binders, coatings and composites. Phenols are a diverse compound group widely available in nature and lignocellulosic biomass as well as an active molecular group available in the distillates at several weight % levels. Thus, they offer a bio-based option for modification of materials.

In this study, we used three different bio-based phenol fractions purified from slow pyrolysis distillates to test doping of 3D printing resins. It was found out that the doping was integrated successfully in the 3D printing and suitable test samples for surface characterization and antimicrobial testing were prepared. Testing revealed that bio-based phenols can be utilized to modify polymer and composite properties and provide enhanced performance in functional testing.

Ultrasonic Surface Modification as a Potential Approach to Counter Hydrogen Embrittlement in Stainless Steel

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The transition to a hydrogen-based economy demands structural materials that can withstand hydrogen-rich environments. Hydrogen embrittlement (HE) remains a significant challenge to the reliable use of stainless steel in structural and energy-related applications. The ingress and trapping of hydrogen can drastically reduce ductility, toughness, and load-bearing capacity. Surface engineering techniques have been widely investigated to address this issue, with a focus on controlling microstructure and residual stresses that influence hydrogen diffusion and crack initiation. Traditional HE mitigation strategies, such as coatings and thermal treatment, often demonstrate limited efficiency or introduce additional manufacturing complexities. Ultrasonic surface treatment (UST) offers a potential alternative by inducing severe plastic deformation, surface grain refinement, and compressive residual stresses that may hinder hydrogen ingress and delay crack propagation. The study aims to investigate the role of UST in tailoring surface integrity and its potential to enhance resistance against HE. The approach is expected to provide valuable insights into the effectiveness of a scalable and cost-effective surface engineering method for enhancing steel durability in a hydrogen-rich environment, while also contributing to reduced resource consumption and supporting the broader goal of sustainable materials engineering.

Addressing Finnish Educators' Eco-anxiety in Secondary Education Level

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This study investigates the emotional challenges teachers face in addressing climate change, focusing on how their professional roles and interactions with students, parents, and the school system influence their experiences of eco-anxiety. Using Panu Pihkala's (2022) "Process Model" and Marja Ojala's (2022) "Critical Emotional Awareness (CEA)" framework, the research examines the causes of teachers' eco-anxiety and the strategies they use to cope. The findings show that teachers feel eco-anxiety not only when students express concern about climate change but also when students appear indifferent, creating a significant emotional burden. Younger teachers, especially those in their 20s, report higher levels of hopelessness, while older teachers with more experience tend to express greater hopefulness and concern. Parental influence and limited institutional support further complicate the issue, leaving teachers feeling constrained in their efforts to promote sustainable behaviours and lacking opportunities to share their concerns with colleagues. Teachers suggest practical solutions, such as sustainability audits, targeted training, and access to mental health resources faster than what current system provides to address these challenges. The study highlights the need for comprehensive support systems that combine action-oriented coping, emotional regulation, and systemic changes to help teachers manage eco-anxiety effectively. Future research should explore the long-term effects of eco-anxiety on teachers' well-being, evaluate the impact of specific interventions, and examine how institutional policies can create more supportive environments for educators.

Performance Assessment of Electrostatic Precipitators for Radioactive Aerosol Mitigation during Severe Accident Scenario

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The effectiveness of electrostatic precipitators (ESPs) in mitigating radioactive aerosol emissions and hydrogen release was examined under various experimental conditions to enhance nuclear power plant (NPP) safety. Key influencing factors—including gaseous environment, relative humidity, flow rate, and temperature—were assessed using caesium iodide as a representative aerosol. Findings demonstrated that ESPs provide high aerosol removal efficiencies, with the laboratory-scale system achieving over 90% particle mass filtration and the industrial-scale unit exceeding 99.5%. Despite this, variations in particle number concentration were observed in the industrial ESP, largely due to its preferential removal of larger particles. This process reduced available condensation sinks, enabling ultrafine particles to remain suspended at higher concentrations.

Hydrogen-related tests showed that ESP operation did not affect hydrogen concentrations under standard conditions. These results affirm that ESPs effectively reduce radioactive aerosol releases without introducing additional hydrogen-related risks.

The study underscores the importance of particle characteristics, carrier gas composition, and device configuration in determining ESP efficiency. It further indicates that while ESPs demonstrate strong performance in controlled settings, their effectiveness is highly dependent on reactor-specific conditions. Consequently, continued research is required to refine ESP applications for severe accident scenarios and to integrate them effectively into source term reduction strategies within NPPs

Biochar – strategic potential for landowners to enhance crop productivity and support carbon sequestration

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What is the strategic potential of biochar for landowners within the evolving landscape of EU climate policy and carbon farming initiatives? Biochar, a stable carbon-rich material derived from thermochemical conversion of biomass (e.g., wood/wood chips, hemp, reed canary grass), offers landowners a multifaceted tool for improving soil health, enhancing crop productivity, and contributing to long-term carbon sequestration. When applied to agricultural soils, biochar improves water retention, nutrient availability, microbial activity, and acts as a carbon storage.

Recent EU legislation, including Regulation (EU) 2019/1009 and the forthcoming Carbon Removal Certification Framework (CRCF), provides a regulatory foundation for landowners to monetize biochar applications through certified carbon credits. Certified biochar use can generate additional income streams via voluntary carbon markets. The CRCF framework emphasizes quantification, additionality, and permanence (≥35 years), aligning with sustainable land management practices.

Landowners are positioned to benefit from the integration of biochar into regenerative agriculture and forestry systems. There also lies potential to utilize biochar as a part of water purification systems. After the purification process, the nutrient enriched biochar is suitable to be returned to the soil as carbon storage. It should be kept in mind to analyze it for potential contaminants, such as harmful substances and heavy metals. In addition, the status of used biochar might change to “waste”, which hinders the utilization potential. It should be considered already during the planning phase, how the biochar will be utilized after the water purification. There lie multiple benefits, both ecological and economic, to build up a closed loop value chain around biochar and support the green transition by utilizing the principles of circular economy.

By adopting biochar technologies, landowners can play a pivotal role in climate mitigation, soil restoration, and ecosystem services, while unlocking new financial opportunities through carbon farming and sustainable biomass valorization.

Particulate Matter Measurement in Residential Wood Combustion: Method Comparison and Introduction of a Novel Approach

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Residential wood combustion (RWC) is a major contributor to ambient particulate matter (PM) pollution, yet inconsistencies in measurement methods hinder comparability and regulatory development. This study systematically compares two PM measurement techniques—(1) a dilution-based method using a porous tube diluter (PTD) and ejector diluter (ED), and (2) the heated filter method defined in the EN 16510-1:2022 standard. Additionally, a novel hybrid method is introduced, combining the EN standard with a PTD to separately quantify solid and condensable PM fractions.

Emissions from six RWC appliances were measured across various combustion phases. Results show that both appliance type and combustion phase significantly influence PM composition, particularly the organic matter (OM) fraction. The dilution method generally yielded higher PM concentrations, especially when OM content was substantial. However, due to the strong dependence on emission composition, universal conversion factors between methods were not feasible.

The hybrid method demonstrated improved capability to capture condensable PM, which was found to contribute up to 64% of total PM. These findings highlight the limitations of current regulatory methods and the need for harmonized protocols that account for condensable particles. The proposed hybrid approach offers a more comprehensive assessment of PM emissions and holds promises for future regulatory adoption.

Statistical Analysis of Emissions from Residential Wood Heating Appliances: Insights from a Large Dataset of Modern Masonry Heaters

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Despite technological advances, user behaviour remains a key driver of emissions from residential wood heating. Misuse or outdated appliances increase both health and environmental impacts. Providing statistically analysed data on masonry heaters can guide emission reductions. We analysed over 700 measurement cycles from 27 masonry heaters in four technology groups, tested according to EN15250:2007. Owing to the hierarchical data structure, a linear mixed-effects model was applied. First, we compared mean emissions with literature values to validate emission levels. Next, we examined how input factors, such as fuel quality and heater technology, influence emissions, and finally, we assessed correlations among emission factors. The air-to-fuel ratio correlated with Carbon Monoxide (CO), Organic Gaseous Carbon (OGC), and Particulate Matter (PM) following a concave polynomial trend, while showing an opposite relationship with Nitrogen Oxides (NOx). Fuel moisture increased CO and OGC, whereas PM was decreased. NOx did not show any clear effect. Longer residence time reduced PM and increased CO, whereas other emission factors showed less consistent effects. Strong relationships were observed among emission factors: CO and OGC correlated with a distinct breakpoint in slope, and PM was associated with elevated CO and OGC above this threshold. NOx emissions were sensitive to ignition protocols, with full primary air at ignition increasing NOx in two technologies, while uniform minimal primary air settings across the cycles mainly reduced it. These findings highlight how design parameters, fuel properties, and user practices jointly influence emissions, and demonstrate how knowledge of one emission factor can help estimate others across different operating conditions.

Modelling CO_2 production rates in forest soil with stable isotope ratios

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Soils are an important source of greenhouse gases such as carbon dioxide (CO_2). The release and uptake of these gases is usually driven by multiple co-occurring processes that follow distinct controls. In upland soils, the efflux of CO_2 consists of autotrophic respiration, that originates from roots and mycorrhizal fungi, and heterotrophic respiration, that originates from decomposition of soil organic matter. While the biochemical reactions underlying these processes are well understood, large uncertainties remain in the functions used to estimate their process rates. To reliably study the rates and the underlaying functions of these processes, there is a need to distinguish between co-occurring processes.

In our study, we develop a time-varying geophysical model that estimates gas production rates of two stable isotopes of carbon,12C and 13C, continuously at different depths of soil. Each of these isotopes has a distinguish fingerprint that can be connected to different respiration processes. The model combines information about gas propagation, including diffusion and porosity, in soil to measurement data of isotope ratio depth profiles, soil surface flux measurements and atmospheric data. We are using statistical state estimation methods to numerically solve gas production rates in soil. From the production rates we separate time-varying autotrophic and heterotrophic respiration at different depths of soil using fractionation and mixing models. In addition to quantifying the respiration rates, we aim to consider and quantify the uncertainties within the model and estimates.

As a result, we are expecting to see seasonal changes in autotrophic and heterotrophic respiration rates locally at the measurement site. From the modelling point of view, we are expecting to create a model that performs well not just in describing present soil conditions, but that also extrapolates well to new conditions, which are expected due climate change and changes in land use practices.

N2O emissions increase after prescribed burning in a dry Scots pine forest

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Forest fires are natural disturbance agents in the boreal region, consuming up to 20 million hectares of forest annually. However, this number is expected to grow as climate change intensifies fire behaviour and increases fire frequency. It is well-established that active burning produces large greenhouse gas emissions, but knowledge of post-fire emissions from burned areas are lacking, especially for the potent greenhouse gas Nitrous oxide (N_2O). While N_2O fluxes from the boreal forest are typically low, fire potentially changes the microbial community, nitrogen availability, and environmental conditions in burned areas, all of which may lead to either increased emissions or enhanced uptake.

To address this knowledge gap, we measured N_2O fluxes using a portable trace gas analyzer before fire and in the first months following fire from both the soil surface and tree boles. The prescribed burn was conducted on 6 June 2024, in a dry pine forest in Leppävirta, Finland. Preliminary results indicate a drastic increase in N_2O emissions from forest soils shortly after fire, but this effect does not persist. This result indicates that increasing fire areas can lead to higher global N_2O emissions from boreal forests. More severe fire behaviour, which increases soil impacts and tree mortality, will also influence post-fire N_2O fluxes. Further research over a longer time scale, as well as diverse forest types, will help us to more widely understand the impact of fires on N_2O dynamics in the boreal forest. By identifying the drivers of these processes, we can improve predictions of feedbacks between boreal forest fires and climate change.

Fire-driven changes in nitrous oxide fluxes from managed and natural peatlands

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In Northern Europe, a vast share of peatlands has been drained for forestry. These peatland forests, with lowered water table levels and thick organic layers, are increasingly susceptible to wildfires as global warming increases the occurrence of forest fires. Peatlands store around 10 % of global soil nitrogen (N), and especially peatland forests may act as sources of nitrous oxide (N_2O), a potent greenhouse gas that also contributes to ozone depletion. Yet very little is known about the effects of wildfires on the N cycle and N_2O emissions from burned peatland sites, even though fires affect multiple factors related to soil N dynamics. To investigate these effects, we conducted a peat column experiment with controlled burning to simulate forest fire conditions.

Peat profiles up to 50 cm depth were collected from three different drained and undrained peatland sites in southern Finland in May 2025 (n = 50). The collected columns were incubated outdoors for three months, and fluxes of N_2O, carbon dioxide (CO_2), and methane (CH_4) were measured weekly. In mid-summer, half of the columns were scorched with a gas torch to simulate a surface fire. At the end of the incubation period, the columns were dissected, and peat samples were collected for analysis of soil physicochemical parameters, microbial community structure, and the quality of soil organic matter.

Preliminary results suggest that nutrient-poor peatlands are negligible N_2O sources, whereas nutrient-rich peatland forests act as N_2O sources under conditions favorable for N_2O production. Burning appeared to shift these patterns, potentially increasing N_2O emissions across peatland types.

Metagenomic insights into the nitrogen cycle and N_2O emission potential of northern agricultural soil

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Nitrous oxide (N_2O) is a potent greenhouse gas and an intermediate in the nitrogen cycle, mainly produced through microbial processes. Agricultural soils are among the largest global sources of N_2O emissions and the emission peaks are strongly influenced by environmental conditions. Predicting emissions and mitigating their impacts require a deep understanding of the microbial mechanisms that drive N_2O production and consumption. In this study, we analyzed soil microbiomes collected from three distinct horizons at the SMEAR-Agri Viikki site in Helsinki, Finland - an area known for episodic N_2O peaks. Sampling depths included the top (0–18 cm), middle (32–70 cm), and bottom (98–135 cm) layers. DNA extraction from the middle and bottom layers was challenging due to low yields, however, the addition of milk powder as a competitive agent to bind positively charged clay surfaces substantially improved recovery. Nitrogen-cycling genes were profiled from Illumina shotgun metagenomes using the NCycDB database. The topsoil, which contained higher concentrations of nitrogen substrates (NH_4^+, organic N, NO_3^-, and mineral N), harbored a greater abundance of genes associated with nitrification and denitrification than deeper layers. Notably, ammonia-oxidizing archaea (AOA), often overlooked contributors to agricultural N_2O emissions, were more prevalent in the top layer than deeper layers, while ammonia-oxidizing bacteria (AOB) dominated the middle and bottom horizons. Although our approach does not distinguish between active and relic DNA, these findings suggest that the topsoil plays a pivotal role in both nitrogen cycling and N_2O dynamics.

Occupational exposure assessment using miniaturized aerosol instruments in different workplace environments

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Occupational exposure to diesel exhaust is regulated by the European Union (Directive 2004/37/EC) due to its carcinogenic effects. Exposure of underground mine workers to diesel exhaust has been reported in many recent studies, but it is not well quantified in other sectors. New miniaturized instruments, such as micro-aethalometers and ultrafine particle counters, are potentially useful for the assessment of occupational exposure to particles.
In this study, occupational exposure of bus drivers, bus depot mechanics, construction workers, street maintenance workers and inspection station workers was measured. Diesel exhaust exposure of the workers was measured as elemental carbon (EC) according to NIOSH5040 method and as equivalent black carbon (eBC) using portable micro-aethalometers (MA200, Aethlabs), and the lung deposited surface area (LDSA) was measured using a nanoparticle detector (Partector 2 Pro, Naneos). Furthermore, ambient air quality in workplace environments was measured, including measurements of eBC, LDSA and volatile organic compounds.
Diesel exhaust exposure was below the occupational exposure limits in all workplaces and was clearly lower than the exposure levels in underground mines measured by Koponen et al. (2024). LDSA and eBC measured correlated well in most workplaces in both the personal exposure measurements as well as the ambient air of workplace environments.
Ångström exponent (AAE) values for most workers were below 1 which indicates that the primary source of the carbonaceous aerosol was traffic. A few construction workers and mechanics had an AAE value 1.2 or higher, which might imply there are carbonaceous aerosol sources in addition to traffic or a higher coating of diesel soot particles by organic matter (Virkkula et al., 2021).
The diesel exhaust exposure levels of the workers were relatively low. The correlation between LDSA and eBC indicates that black carbon plays an important role in exposure to fine particles in the studied workplaces.

N2O-Predict: Predicting episodic N_2O emissions from northern agricultural soils

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Agriculture can play a crucial role in mitigating climate change through practices reducing greenhouse gas emissions and enhancing carbon sequestration into soil. However, mitigating nitrous oxide (N_2O) emissions and verification of the mitigation has been proven challenging due to the poorly predictable and episodic nature of the emissions.

To address these complexities, the N_2O-Predict consortium unites a multidisciplinary team of scientists from the University of Helsinki, the University of Eastern Finland, the Natural Resources Institute Finland and the Finnish Meteorological Institute. The overarching objective of N_2O-Predict is to quantify the seasonality, budgets and drivers of N_2O emissions in northern agricultural soils. With field and laboratory measurements, we also aim to uncover the legacy effects of farming practices and weather on N_2O formation, particularly during the episodic emission events of freezing-thawing and drying-wetting of soils. We will integrate the gained new knowledge into biogeochemical process models to predict N_2O emissions in future climate conditions. Our research employs cutting-edge methods, including isotope biogeochemistry, metagenomics, flux measurements using eddy covariance and chambers, and ecosystem-scale process modeling.

Here we present the first results from the field and our concepts to study the episodic N_2O emissions and processes. Finally, our synthesis of multi-year and multi-site analysis will provide a comprehensive understanding of the role of N_2O emissions in the climate impact of northern agricultural soils and offer predictions for future emissions.

N_2O and CH_4 cycling within the canopies of tropical trees in the Peruvian Amazon wetlands

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Tropical forests comprise a large proportion of the global forest area. They have the potential to serve as both sinks and sources for nitrous oxide (N_2O) and methane (CH_4) and may thus significantly impact the global greenhouse gas (GHG) balance. However, despite the importance of these ecosystems, and their vulnerability to the climate change, tropical forests are still relatively poorly described in terms of biogeochemistry. Particularly, we lack studies on the role of above-ground vegetation.

We explored tree canopies and their GHG cycling dynamics on two peat swamp forest sites in the Amazon, Iquitos, Peru: a natural protected palm swamp reserve, Quistococha, and as a reference, Zungarococha, a secondary peatland forest. During two campaign trips (Nov 2023, May 2024), we evaluated potential N_2O and CH_4 production and/or consumption from the leaves/twigs of 3-4 tree species (on-site aerobic 48-h bottle incubation with daily gas sampling to GC-vials). In addition, nitrogen (N_2) fixation was tested on-site via 15N-isotope labeling (72-h, 12-ml vials). From the same branches, samples were collected for a metagenomic analysis of the epi-/endophytic microbiomes.

Preliminary results showed small but significant emissions of both gases in the leaves of all tested tree species. Twigs showed opposing trends: Hevea sp. was a small sink for both gases, and Symphonia sp. a source. Variability was high between tree species, but also in the same species between sites. Nitrogen fixation was active in three of the four tree species. Preliminary microbiome results showed genetic potential for all the screened denitrification steps and for the N_2 fixation, while nitrification genes (amoA) were almost absent.

This study provides novel insights on the GHG processes, and the related microbial communities of the tropical tree canopies. As such, it will aid in gaining a holistic understanding on the ecosystem-level GHG balance and its drivers.

Freeze-thaw cycles stimulate N_2O production and shift N_2O production pathways in two boreal agricultural soils

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Freeze-thaw cycles (FTC) are periods of elevated N_2O emissions, but it remains unclear whether these emissions are produced de-novo or if N_2O accumulated in frozen soil is released during thaw periods. Similarly, it is not known whether repeated FTC alter N2O source processes.

Here, we report on a laboratory experiment with soil cores (ca. 100 cm3) from two agricultural fields with mineral (Viikki) and peat (Ruukki) soils. Samples were collected from frozen soil during late winter (March) and stored at -5 C prior and place in 800 mL air tight canning jars for incubation. Three samples from each site were then incubated as follows 48 hours at +4 C, 48 hours at -4 C, 72 hours at +4 C, 72 hours at -4 C, 48 hours at +4 C. Another three samples were kept constant at +4 C. Headspace N_2O concentration and stable isotope ratios (δ15N, δ15N site preference, δ18O) were measured approximately once every 4 hours by cavity ring-down spectrometer (Picarro G5131-i).

Viikki soils acted as small sources of N_2O when kept at constant +4C, whereas Ruukki soils were net N_2O sinks. Freeze-thaw cycles increased N_2O emissions at both site during thaw periods, demonstrating the stimulate of de-novo N_2O production by freeze-thaw cycles. Only Viikki soils in freeze-thaw treatments produced sufficient N2O for measuring stable isotope ratios. For N_2O emitted during the first thaw cycle, we find +10 ‰ (δ15N), -6 ‰ (δ15N site preference), and +25 ‰ (δ18O). N_2O released during the second and third thaw period had lower δ15N values (-14 ‰) pointing towards a change in the dominant N_2O source process.

Source process partitioning model FRAME indicated that denitrification was main source during all three thaw periods, that that contributions for nitrification to N_2O emissions further decreased after the first thaw period.

Effects of traffic-related air pollution on pollinator communities associated with keystone boreal plant Angelica sylvestris

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Atmospheric pollution affects and modifies plant-pollinator interactions, essential for plant reproduction and food security. However, little is known about how heavy metals (HMs), which are part of atmospheric particulate matter pollutants (PM2.5/PM10), affect insect pollinator communities in keystone plant species. Traffic areas cause habitat fragmentation and produce changes in soil, as well as air pollution due to gaseous and particulate pollutants. Wild angelica (Angelica sylvestris, Apiaceae) is a keystone boreal plant that provides food and shelter for dozens of insect species. It often grows in traffic areas. Due to its ability to attract many insect taxa, it is recommended as a "magnet" species in restoration projects alongside other flowering species from the Apiaceae family. We aimed to determine whether the abundance, richness, and diversity of insect communities attracted to the highly nectar-rewarding male flowers of wild angelica differed between traffic and control areas and whether those communities were affected by levels of HMs in flowering umbels. A total of 70 wild angelica plants were studied in ten locations, which were divided into two types: traffic and control sites, in Kuopio. To study insect abundance, richness, and diversity, two sampling sets were systematically collected from all habitats from July 15th to July 31st using the sweep net method along transects. HMs (n = 11) in plant umbels were analyzed using inductively coupled plasma mass spectrometry (ICP-MS). A total of 353 insect specimens were collected. The abundance, richness, and diversity of pollinators did not differ between locations and were not associated with umbel HMs. A. sylvestris has an intense but relatively short flowering period (up to four weeks), which may prevent the accumulation of HMs and the disturbance of insect communities. Our results highlight the essential conservation potential of this keystone plant, even in polluted and disturbed environments like traffic areas.

Designing Ce-Ni/$MgCo_2O_4$ Catalyst for Efficient CO_2-Methanation

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The catalytic conversion of CO_2 to CH_4 is a promising strategy for mitigating greenhouse gas emissions while facilitating renewable energy storage. However, the efficiency of CO_2 methanation is strongly influenced by catalyst design, which is often limited by coking, sintering and agglomeration of active sites. In this study, we designed a Ce-Ni/$MgCo_2O_4$ catalyst exhibited activity, delivering 85% CO_2 conversion to CH_4 and 98% selectivity at 350 °C with a GHSV of 60,000 mlgcat-1 h^{-1}. The high performance could be attributed the synergistic effects of CeO_2, generate the oxygen vacancies that promote CO_2 activation, improve Ni dispersion, and donate electron density to enhance hydrogenation. More importantly, $MgCo_2O_4$ spinel support could play pivotal role in providing a high surface area which facilitates the dispersion of Ni nanoparticles, moderate basic sites for CO_2 adsorption, redox activity from Co for H_2 activation, and strong thermal stability that suppresses Ni agglomeration. These findings highlight CO_2-methanation as a sustainable route for carbon recycling and synthetic natural gas production, offering strong potential for integration into power-to-gas technologies and carbon management strategies.

Real-Time Spatial Mapping of Metal Contamination in Environmental Waters for Sustainable Ecological Predictive Monitoring Using a Portable XRF Device

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The monitoring of metal pollution in environmental waters is crucial for the protection of ecosystems, human health and agricultural activities. Traditional laboratory-based metal analysis methods are time-consuming and expensive, which often leads to delays in the availability of information. This study presents a new approach to real-time water quality monitoring using portable X-ray fluorescence (p-XRF) technology coupled with geographic information systems (GIS). Using a custom Python script, p-XRF data is processed and formatted into a GIS-compatible format, facilitating spatial visualization of metal concentrations in QGIS. Field-usable filters, especially bisphosphonate-functionalized thermally carbonized porous silicon (BP-TCPSi), preformed metals such as Mn, Ni, Cu, Zn, and Pb allow direct detection in the field by using p-XRF. Key objectives include robust data collection, spatial visualization and validation processes to ensure accuracy and efficiency. This provides quick and efficient insights into metal contamination trends and allows proactive decision-making.

A human skin cell model for screening the safety of components for novel bio-based coatings and composites

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A common goal worldwide is to increase the use of renewable bio-based resources, to which biorefining provides one solution. Novel bio-based coatings and composites are being engineered at an increasing rate. Safety assessment, already at the product development stage, is imperative for bio-based materials, although they might be more easily perceived as safe compared to conventional options.

To gain insight into the skin safety of bio-based coating and composite components, an in vitro human dermal-epidermal co-culture model was developed. The cell model represents the human skin, consisting of human BJ fibroblasts and HaCaT keratinocytes. Importantly, the sample exposure is executed in air/liquid interface, thus simulating a real-life situation. For feasibility studies, the model was exposed for 24 hours with increasing doses of wood- and hemp-based slow pyrolysis distillates which were produced from typical industrial side stream materials.

The effects of the distillates were studied by measuring the viability, metabolic activity, oxidative stress, cell cycle profile, inflammatory responses, and wound healing activity of the cells. The results indicated that the cell model is suitable for screening sample safety and that the distillates did not cause major safety concerns at the lowest concentrations.

The distillate samples represented a potential additive for bio-based coatings. Next, the cell model is utilized to study biochar particles, which is important due to the increasing use of biochar and its potential in coating and composite development. Lastly, selected natural fibers for composites will be similarly screened. This cell model, in combination with other assays like antimicrobial tests, can provide necessary information on the properties and safety of novel bio-based materials.

Physiological differences in Saprolegnia spp. strains isolated from Finnish aquaculture facilities

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Saprolegniosis is a disease caused by Oomycetes, characterized by lesions and cotton-like growth on the gills, skin, and eyes. Saprolegniosis causes massive economic damage to aquaculture industry, in addition to causing mass-mortalities in both wild salmonids and endangered broodstocks kept in aquaculture facilities. Saprolegnia parasitica has been identifed in most saprolegniosis outbreaks of fish in Finland and the pathogen compromises the restoration and existence of Finland's most endangered fish populations, particularly the landlocked Atlantic salmon in Vuoksi watercourse (status: CR). Previous studies have shown variable results between different Saprolegnia spp. strains in their growth and sporulation, but less is known about possible trade-offs between the physiological traits. Understanding these strain-level differences of Saprolegnia spp. could improve disease management strategies in the future. In this study, nine Saprolegnia parasitica strains, and one Saprolegnia diclina strain were collected from seven anonymous aquaculture facilities from different geographical regions of Finland. S. parasitica samples were isolated from four different host species (brown trout Salmo trutta, Atlantic salmon Salmo salar, Saimaa landlocked salmon Salmo salar m. sebago, and rainbow trout Oncorhynchus mykiss) and S. diclina from rainbow trout eggs. Hyphal growth, sporulation timing, spore production and number of repeated zoospore emergence cycles were measured from all the strains in a controlled laboratory setting. Comparisons between strains and potential trade-offs between the different physiological traits were investigated using generalized linear mixed effects models. We observed significant differences in physiological traits and found a trade-off between hyphal growth and repeated zoospore emergence. The significant variation in the physiological traits suggests potential virulence differences among the strains making it imperative to examine whether such virulence differences also translate to host specific responses and if aquaculture environments could favor evolution of high virulence; the findings highlight the need for more research of strain-specific effects of Saprolegnia spp. in aquaculture.

Influence of In:S Ratio on the Photocatalytic Performance of MIL-100(Fe)/In2S3 Composite for Diclofenac Removal

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Indium Sulphide (In2S3) is a non-toxic, n-type semiconductor with narrow band gap (2.0-2.4 eV) and has been considered as a potential photocatalyst due to its excellent chemical and physical characteristics. However, In:S stoichiometry not only affects particle morphology, crystallinity, and photocatalytic efficiency, but also critically influences interfacial contact when In2S3 is combined with other materials to form composites. In this research, we investigated the effect of In:S ratio on the photocatalytic efficiency of MIL-100(Fe)/In2S3 composite. In2S3 was synthesized via hydrothermal method with three different precursors ratio (In/S ratio = 0.71, 0.5, and 0.33). The precursors of In:S were incorporated with pre-synthesized MIL-100(Fe) via one-pot hydrothermal method to form 30 wt.% MIL-100(Fe) composite. The synthesized materials were characterized using Field Emission Scanning Electron Microscopy (FESEM) to examine surface morphology and Fourier Transform Infrared Spectroscopy (FTIR) to confirm chemical interaction between In2S3 and MIL-100(Fe). Band gaps were determined using UV-Vis reflectance spectroscopy. Photocatalytic performance of synthesized materials was evaluated using diclofenac. Result shows that 30 wt.%. MIL-100(Fe)/In2S3 composite with an In:S ratio of 0.5 shows highest photocatalytic degradation, with a reaction rate constant of 0.0198 min-1. This research provides insight on the role of In:S stoichiometric ratio in tailoring the properties of MIL-100(Fe)/In2S3 composite for enhanced photocatalytic removal of diclofenac.

Bioluminescent ATP assay for monitoring industrial water quality for microbes

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Bioluminescent determination of adenosine triphosphate (ATP) is one of the few methods that have been used for many decades to assess microbial contamination of industrial water. ATP is an energy carrier molecule present in all living cells and can be considered an energy unit in biological systems and an indicator of life processes. Uncontrolled microbial growth in industrial water results in additional costs for biocides, interruptions in the production process and additional cleaning procedures. Monitoring microbial growth allows for optimization of the production process and minimization of the use of poisons and harmful substances, which simplifies the subsequent water purification procedure.
The presence of various inhibitors of the luciferin-luciferase reaction, on which the bioluminescent analysis of ATP is based, in industrial water samples can make the measurement of ATP incorrect or even impossible. A special place among inhibitors is occupied by divalent ions. In particular, an excessive concentration of the Mg2+ ion, which is an obligatory participant in the enzymatic reaction and is already present in the ATP reagent, can affect the final measurement result. The inhibitory effect of divalent ions on the luminescence intensity and amount of ATP was studied, and acceptable concentrations of divalent ions in industrial water samples for monitoring microbial bioluminescence of ATP were proposed. Various examples of correct interpretation of ATP measurement results for different types of samples were also given.

Toxicity of Tire Rubber Leachate to Daphnia magna and the Temporal Trends of Additive Leaching

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Tire rubber (TR) is a semisynthetic polymer with varying physical and chemical properties. It consists not only of polymer chains but also of many kinds of additives that are used to modify properties of the rubber mass. These additives are not chemically bonded to the TR and can leach out over time, thus causing harm in the environment. In our study, we wanted to assess the toxicity of TR leachates to the water flea Daphnia magna. We also wanted to evaluate temporal trends of additive leaching and elucidate the molecular identity of additives released.

Tire rubber leachate was prepared in medium-high concentration (10 g/L) over six subsequent 20-day leaching cycles. After each leaching, the toxicity of obtained TR leachate was tested on D. magna neonates (< 24h old) in different concentrations by monitoring their mobility at 24 h and 48 h according to the OECD guidelines. The leachates were characterized using untargeted high-resolution LC–MS to elucidate the identity of the organic additives released. Leachate characterization data from the untargeted analyses is currently being analyzed and will later be complemented with ICP–MS analyses for the metal content determination.

Our results show that the first TR leachate can induce acute immobilization of D. magna already at 5% concentration, and the observed toxicity begins to diminish from the third leaching onwards. Our preliminary results indicate high levels of both 1,3-diphenylguanidine, a common tire rubber vulcanization agent, and 4-hydroxydiphenylamine, a toxic degradation product of the antiozonant 6PPD. However, the metal analyses and additional toxicity testing using the potentially hazardous candidate molecules must be performed before drawing any conclusions.

Overall, our study demonstrates the important role of TR-derived chemicals in ecotoxicology and the hazards they may pose to the environment already at relatively low concentrations.

Engineering Anion–π+ Interactions Through Isomer Design to Modulate Efficient Luminescence in Bisphosphonium Salts

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Phosphorescent molecular materials attract constant attention as their utilization spreads across various high-end technologies such as sensors, displays, bioimaging, and phototherapy. Developing efficient, easy-to-synthesize, and eco-friendly luminophores is necessary, as these technologies should follow a net zero-emission objective of the EU directive by 2050. In this regard, phosphonium species, which are composed of organic π-conjugated cations and inorganic anions, can become superior candidates due to two main reasons. First, their rigid, solid-state ionic structure blocks non-radiative transitions, resulting in increased efficiency. Secondly, the structures of both constituents can be easily modified to give rise to tunable optical properties. Importantly, the anions can be altered from simple halides or their inorganic counterparts, increasing the number of heavy atoms. This allows for modulating the intersystem crossing rate, potentially increasing the ability to harvest triplet excitons more efficiently.

As the optical properties of such ionic luminophores arise from the interplay of the two constituents, we have designed and tested a series of ionic pairs consisting of a naphthalene-based bisphosphonium cation and different heavy counterions, including halides (Br or I) and complex metallates (CdI_4^{2-}, $ZnBr_4^{2-}$). In the solid state, these species exhibit high quantum yields, reaching 75% and fast radiative rates of up to 2.1×10^5 s^{-1}. The lifetimes of the excited state vary from 1.3 μs to 2.4 ms, while the emission maxima span from 542 nm to 568 nm.

Our strategy paves the way for sustainable efficient luminescent materials with a high degree of tunability suitable for optronics.

Photoemissive silver and gold phosphane-phosphinic acid complexes

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Luminescent transition metal complexes constructed of multidentate ligands are an important class of photofunctional molecular materials. The structural diversity of multidentate ligands and their rich coordination chemistry enable fine control over the (photo)physical and chemical properties of the resulting compounds. Among the most widely applied building blocks are phosphines, which are particularly effective in stabilizing late transition metal derivatives (Cu, Ag and Au). Soft phosphine ligands offer flexible stereochemistry and coordination modes, while mixed phosphane ligands that also contain P(V) acidic groups (phosphinous, phosphinic, or phosphoric functions) provide additional opportunities for tuning molecular interactions. In particular, the P–O fragments of such ligands form strong hydrogen bonds, which can significantly influence both intermolecular packing and the photophysical behavior of metal complexes. Recently, we demonstrated that incorporating a phosphide oxide group into a phosphane scaffold can strongly enhance luminescence and photocatalytic activity in Ag(I) complexes. Building on this, we now introduce a hybrid phosphane–phosphinic acid ligand, in which the additional oxygen atom of the POO– group increases coordination flexibility and hydrogen-bonding capacity. Using this approach, we prepared new silver and gold complexes Ag(I)/Au(I)-P3OOH. Their structures and emission properties are regulated by reversible coordination and hydrogen bonding. Importantly, such ligand systems illustrate how rational molecular design can support the development of more sustainable photonic and catalytic materials.

Vapochromic luminescence of a copper(I)/ sodium phosphine iodide complex

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Luminescent transition metal complexes showing reversible switch of the emission color in the solid state upon exposure to volatiles are intriguing molecular materials due to their potential applications in chemical sensing and optical monitoring devices. Such vapochromic behavior has been extensively studied among Au(I), Ir(III) and Pt(II) complexes, for which it is often associated with alterations of metal-metal interactions, molecular packing and solvent-emitter communication. As these metals are rare and expensive more sustainable options need to be studied.

Due to the high natural abundance and relatively low cost, Cu(I) compounds form another actively investigated class of luminophores. Electronic transitions in molecular Cu(I) complexes, which account for light absorption and emission, have metal to ligand, ligand to ligand and intraligand charge transfer (MLCT, L/XLCT, ILCT) character. In addition, optical response of these compounds to vapors and/or mechanical input therefore is primarily related to the perturbation of ligand environment.

We have investigated the coordination chemistry of the sodium salt of the orthogonal phosphine-phosphinate ligand, [P^{3}OO]Na, towards CuI. The resulting copper/sodium iodide phosphine-phosphinate assembly shows intense solid-state luminescence, which is governed by intramolecular sodium-π and sodium-iodide interactions and is switched by vapors of hard oxygen-donor molecules (i.e., methanol, ethanol, dimethoxyethane). Exposure to these vapors changes the maximum emission from 461 nm to 565 nm, with a quantum yield reaching up to 73 %.

This wide emission color tunability via solely vapor exposure provides new insights into the development of sustainable stimuli-responsive optical devices when constructed of abundant materials.

Biodegradable ionic luminophores: a versatile sustainable platform for optronic

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Luminescent materials occupy a central position in contemporary materials science and technology, underpinning applications ranging from energy-efficient lighting (LEDs, OLEDs) and high-resolution displays to bioimaging, drug delivery monitoring, stimuli-responsive systems, and biochemical sensing. In response to growing societal needs, the demand for sustainable technologies has redirected the research frontier toward the development of next generation luminophores guided by the principles of green chemistry. Achieving this remains a formidable challenge: the design of high-performance materials must be reconciled with requirements for low toxicity, cost-effectiveness, minimal environmental persistence, and compliance with the 10th principle of green chemistry. Ideally, such materials should generate minimal waste during synthesis and degrade into non-toxic byproducts at the end of their functional lifespan, thereby avoiding long-term accumulation in the environment.

To address this challenge, the present study explores the synthesis and biodegradation of pyridinium-based ionic compounds as potential sustainable luminophores. Pyridinium cores were selected as a versatile platform due to their (i) facile, one-step modification, (ii) high structural tunability, and (iii) outstanding photophysical properties of resulted ionic pairs, including rapid emission dynamics, tunable emission colors, and high quantum yields. The target pyridinium salts exhibit extensive anion–π interactions, which promote charge-transfer excited states and enhance luminescent behavior. A series of derivatives bearing electron-withdrawing substituents were synthesized via methylation and fully characterized using scXRD, pXRD, NMR, TGA, DSC, and elemental analysis.

Sustainability was evaluated through biodegradability testing, employing a modified OECD 311 Anaerobic Biodegradability of Organic Compounds in Digested Sludge assay. Biodegradation performance was assessed through substrate utilization, gas production, metabolite profiling, and quantitative analysis of degradation rates. These findings provide valuable insights into the rational design of luminescent ionic compounds that combine high photophysical performance with environmental responsibility, thereby contributing to the advancement of sustainable materials for future technologies.

Exploring the Eddy-Covariance N_2O data from six Finnish sites

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The increasing need in food supply is putting a strain on croplands worldwide, which in turn raises the questions about the evolving climate effects of agriculture. However, an important component of this problem, the nitrous oxide (N_2O) emissions, are known to be difficult to explain and predict compared with other greenhouse gases. This is particularly true of agricultural ecosystems, where the N_2O cycling has a complicated relationship with the periodicity and amount of fertilizer input, crop, weather conditions, management and soil type.

Within the framework of the project N_2O-Predict, a new work to compile, harmonize and explore the N_2O emissions data from Finland has begun. At the initial stage, the effort uses the total eddy-covariance (EC) N_2O measurement data produced in the sites managed by the Natural Resources Institute Finland (Luke). This includes the Anttila, Jokioinen, Pappilansuo, Ränskälänkorpi, NorMi and Särkisuo facilities, with a total of 24 site-years of EC N_2O measurements.

A uniform analysis is performed on all the available data in order to explore the details of N_2O emission events. The study takes advantage of the high temporal resolution and continuity of EC measurements to investigate the diurnal to seasonal variability of the fluxes. The possible spatial hotspots of N_2O emission are tested for by means of flux footprint analysis. The effect of concurrent weather conditions, crop type and phenology on the magnitude of N_2O efflux is discussed.

Building Networks for Nature-based Solutions: The UEF Living Lab

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In this presentation, the eNaBLS/EU-Horizon project's UEF Living Lab will be introduced. eNaBLS aims to tackle urgent sustainability challenges by fostering networking and collaboration to promote transdisciplinary dialogue and embed Nature-based Solutions (NBS) concepts within universities, vocational schools, the professional sphere, and society at large. Through Living Labs in seven European countries, the project advances NBS as a pathway to biodiversity preservation, climate resilience, human well-being, social equity, and green employment.

At the University of Eastern Finland (UEF) Living Lab, our goal is to create a hub where stakeholders interested in NBS can connect and collaborate. During the first year, we developed a multidisciplinary introduction course on NBS, engaged in campus events, organized hybrid meetings, and facilitated research site visits for students and staff. We have supported researchers working on NBS and students in finding thesis opportunities. Looking ahead, we aim to amplify this impact by hosting a large-scale networking event that brings together students, staff, and organizations working with NBS, complemented by smaller hybrid sessions showcasing Living Lab outcomes. Through these activities, the UEF Living Lab seeks to advance knowledge exchange, foster collaboration, and accelerate the integration of NBS into education.

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