4th International Conference

Strategies toward Green Deal Implementation

Water, Raw Materials & Energy

ABSTRACT BOOK

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4th International Conference
Strategies toward Green Deal Implementation
Water, Raw Materials & Energy

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Division of Biogenic Raw Materials

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Division of Biogenic Raw Materials conducts research in the field of environmental management and engineering as well as biotechnology. The special interest is dedicated to the Circular Economy (CE) model and the Green Deal Strategies in food, water and raw materials sectors.

Division of Biogenic Raw Materials specialises in the analysis and assessment of specific problems and phenomena related to the management of fertiliser raw materials, with particular emphasis on phosphorus, nitrogen and potassium. A special area of interest are issues related to sustainable and circular management of the raw materials in order to optimise the use of resources at the local, regional, national and international levels.

The division's work includes:

- development of recommendations (road maps) for sustainable and circular management of biogenic raw materials;
- recovery of raw materials from waste, including phosphorus from waste generated in the water and sewage sector (fertilisers from waste);
- water in a circular economy and water footprint;
- assessment of technological, legal, environmental and social aspects of biogenic raw materials management;
- strategies for water protection against pollution with biogenic raw materials from anthropogenic sources and determination of directions for counteracting eutrophication;
- analysis of new materials (including nanomaterials) used in municipal and industrial sewage and soil treatment processes.

Division of Biogenic Raw Materials participates in international projects (Horizon 2020, Horizon Europe; EIT Raw Materials, NAWA, Visegrad Fund, Norway Grants) related to the management of phosphorus raw materials and the development of recommendations (roadmaps) for the management of raw materials in the context of implementing the assumptions of sustainable development (SD), circular economy and the European Green Deal in the water and sewage, fertiliser and agri-food sectors.

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Introduction

In 2023, as part of the 4th International Conference Strategies toward Green Deal Implementation – Water, Raw Materials & Energy (ICGreenDeal2023), we continued the debate on the Green Deal strategies in management of water, raw materials and energy. The purpose of our conference was to present the importance of climate change and ways to prevent it via various technological and non-technological solutions that could be implemented under the Green Deal Strategies.

This book presents abstracts of all the speeches (oral and poster) during ICGreenDeal2023 that took place 14-15 December 2023, as online event. Once again, the most popular topics were:

- circular economy (CE), including the use of various waste streams to recover and recycle valuable raw materials;
- water and sewage in CE, including rational water management and recovery of water and raw materials generated during water usage;
- energy management, including energy efficiency of environmental engineering installations, as well as energy recovery.

During the two days of the conference, 14 thematic sessions were held, attended by more than 200 speakers (during oral and poster sessions) and 350 registered participants.

I would like to thank all Participants – both Presenters and Listeners for preparing valuable speeches and taking part in discussions and exchange of information about green deal solutions.

Once again we have proven that we want to work together to save the Planet!

Prof. Marzena Smol

ICGreenDeal2023 Chairwoman

Green Deal Strategies

Plenary session

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Green Deal Strategies in the management of Water, Raw Materials and Energy

The work presents an introduction to the conference theme, emphasising the role of the Green Deal strategies and their origins. The concept of the Green Deal has been known to politicians and scientists for many years. Its beginning can be traced to the concept of the New Deal, initiated in the United States in the 1930s by President Roosevelt, as a response to the Great Depression - with rising unemployment, falling production in the economy and a drastic increase in public debt. In those days, the New Deal referred to a set of economic and social reforms, supported by public works projects, while environmental aspects were not taken into account. In fact, the idea of taking environmental aspects into account appeared in late 2000s, as an answer for the global financial crisis of 2007–2008. During this time, several Green Deal concepts emerged promoted by various government and non-governmental agencies, such as the concepts of "green deal", "green new deal" and "global green new deal". These concepts emphasize the role of sustainable development, which should integrate environmental, social and economic aspects. To achieve this, it is necessary to ensure access to water, raw materials and energy for current and future generations. Therefore, the topics of 4th International Conference "Strategies toward Green Deal Implementation – Water, Raw Materials & Energy" include these three areas, within which various solutions are presented - technological and non-technological. They can be treated global directions to protect our planet for both current and future generations.

Keywords: green deal; green deal strategies; sustainable development

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Importance of Raw Materials in Green Deal Strategies - Socio-economic challenges in the transition to the Circular Economy

The global community has agreed on the Sustainable Development Goals and the European Union has set the Green Deal covering various strategies towards a Clean Planet for All. Climate change and biodiversity loss present many challenges to be encountered, among others, by the Critical Raw Materials Act. Low carbon lifestyles require to phase out fossil fuel combustion and to convert hydropower, wind, sun and biowaste to usable energy. Zero emission energy requires replacement of 15 million tons of fossil fuels by 3 million tons of sometimes critical raw materials. While the gaseous residue of fossil fuel combustion (CO_2) is causing global warming due to its increased concentration in the atmosphere, materials can and must be recycled.

EU wide goals and procedures are laid down in the Critical Raw Materials Act, albeit counteracting trends are currently prevailing in Europe. Excessive energy prices lead to closures of energy intensive production sites needed for resilient supply chains and future materials recycling. For instance, significant ammonia production facilities have been decommissioned and will not come online again due to EU gas prices being 5-times higher than in the Americas and other world regions. Few politicians propose transient subsidising energy prices for selected industries in exchange of commitments to invest in renewable energy supplies but the majority refrains from market interventions. This is unfortunate for the efforts to abate greenhouse gases as European supplies are replaced by others, including Russian, typically more polluting and less climate friendly. The good news is that some industries such as the fertiliser industry have made commitments to zero emissions by 2050, despite Europe remaining rather unfavourable regarding low-cost renewable energy. Fertiberia is now operating the first full-scale zero-emission “Green Ammonia” production in Puertollano (Spain). The technical potential for N recovery from secondary resources and producing so-called “White Ammonia” is significant but currently economically not viable. Fertilisers are needed for food security.

Materials needed for energy conversion and storage must first be mined before they can be recycled. The Critical Raw Materials Act proposes at least 10% of strategic raw materials to be mined and at least 40% processed in the EU. Horizon Europe projects (e.g., CIRAN https://ciranproject.eu/) are underway to reconcile mining with nature protection, including in protected areas - raw materials are immovable, you must extract them where they occur. The mining industry (ICMM https://www.icmm.com/) has launched its sustainable mining principles in 2020 and a corresponding action plan in 2022. Not to forget, Europe has a material mining transition going back thousands of years and some of the ancient mining sites are now cultural heritages. Mining – and recycling – must be supported by a higher material use efficiency, i.e., by decoupling materials use from their function and from economic growth. New business models such as Resources as a Service (RaaS) are suitable to shift the industry interest from selling higher commodity volumes to use all available tools (e.g., sensors, controlled delivery, big data, AI) to achieve maximal impact (e.g., fertile soil) with minimal use of materials.

Keywords: critical raw materials; sustainable development goals; circular economy

Acknowledgments: This study has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818309 (LEX4BIO).

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Importance of Sustainability in Green Deal Strategies

Presentation included a three-dimensional research framework, wherein Theme 1 explored Blockchain applications within supply chains, Theme 2 emphasized the adoption and practical applications of Circular Economy concepts in contemporary businesses, and Theme 3 underscored the synergies between Blockchains, Industry 5.0, and Circular Economy principles for advancing sustainable development goals.

This comprehensive session shared insights from research of the Research Centre at Thiagarajar School of Management in Madurai, India, particularly highlighting contributions to overcoming barriers associated with implementing Blockchain applications in supply chains and within the context of Society 5.0. Additionally, a critical review of research pertaining to reverse logistics and closed-loop supply chains from a Circular Economy perspective, culminating in a notable research achievement: the analysis of driving forces that enable Circular Economy practices among Small and Medium-sized Enterprises (SMEs) were presented. Furthermore, the relationship between Blockchains and Circular Economy by referencing recent research on the critical success factors for implementing Blockchain-based Circular supply chains was discussed. Moreover, the intricate interplay between Industry 5.0 concepts and Circular supply chains in the context of sustainable development was presented. This enlightening keynote address encouraged collaborative research endeavors within the realm of Circular Economy and Blockchain, with the overarching aim of reducing carbon footprint in an Industry 5.0 scenario representing a strategic approach to Green Deal initiatives in the pursuit of Sustainable Development goals.

Keywords: Blockchain; Industry 5.0; circular economy; sustainable development goals

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Importance of Water in Green Deal Strategies - Water City Index

Adaptation of cities leads to the evolution of understanding of their functionality and development. They should transform from conventional, through green and sustainable, to regenerative cities, characterized by a symbiotic, mutually beneficial relationship with their surroundings. The Water City Index aims to answer how far Polish towns are from transforming into regenerative.

Water City Index 2023 was prepared based on the method used in previous rankings. It is divided into 3 categories (Life, Hazard, Economy & Society), and 13 assessment subcategories. A great emphasis was placed on measuring the activity of local governments and the direct effects of their policies using indicators that show changes in their values. The Water City Index is prepared for three categories of Polish cities: metropolises, towns with county rights, and other medium-sized cities. It is a quantitative ranking. The results are prepared in a maximally objective way by obtaining the most up-to-date, comparable indicators from various databases and information developed through surveys.

The ranking results show that despite thousands of years of civilisation development, natural conditions are still a strategic criterion for the quality of cities' functioning. This is especially visible now when climate change has significant negative consequences in places where biodiversity has not been preserved. Polish local governments are increasingly aware of the threats resulting from climate change. Moreover, the WCI exposes the growing financial dysfunctionality of municipalities. The Act on Spatial Planning and Development favors chaotic and thoughtless development, especially short-term benefits compared to responsible development or maintenance of developed blue-green infrastructure.

Keywords: regenerative city; WCI; ranking

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Water in Green Deal Strategies

Parallel session

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How to deal with the "yuck factor" in water reuse?

Water recovery from urban wastewater is one of the circular economy solutions mainly implemented at the local level (municipality). Risk assessment in water reuse is critical in building sustainable solutions in urban water management systems. It is focused mainly on technical aspects related to the reliability of technology, infrastructure, and monitoring of the quality of reclaimed water. However, in risk management, it is impossible to ignore social aspects related to building public awareness and recipients' trust in reclaimed water suppliers and in products made using this water (seeds, plants, snow, bathing water, drinking water, etc.). Strategies related to the transparency of the operation of water reclamation plants are therefore crucial from the beginning of the process of local solutions.

The authors present and comment on case studies from different countries, pointing out the strengths and weaknesses of implemented solutions. They also present the problem of misunderstanding between stakeholders and suggest strategies that may be useful in developing water recovery at a municipal level. Building trust in unpopular solutions should be based on the simplicity and transparency of the message. It is also essential to be supported by authorities not necessarily closely related to the water industry. The review of case studies shows that starting communication with the stakeholders too late, lack of social awareness, and belief in false information are substantial barriers to the success of closing local water cycles. Due to climate change and natural water resource shortages, educating the public and working closely with stakeholders is necessary.

Keywords: reclaimed water; safe water; risk management

Acknowledgments: This presentation was prepared as a part of the project "Closing local water circuits by recirculation nutrients and water and using them in nature" (ReNutriWater) financed by European Regional Development Fund (ERDF), project no. #C016.

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Contamination of drinking water with endocrine active compounds included in the watch list of Directive (EU) 2020/2184

With the development of medicine, industry and breeding, water pollution in rivers and reservoirs, which are a source of drinking water, increases. For water supply companies, the most important goal under the law is to provide a product that is safe for consumers' health. We observe a dynamic change in regulations specifying the quality requirements for drinking water. The extension of the scope of water quality monitoring to include the so-called newly emerging pollutants is an important element in the new DWD ((EU)2020/2184 of December 23, 2020). WHO has not provided recommended values for endocrine-active compounds (EDCs) that disrupt the functioning of the endocrine system. However, to protect aquatic organisms and humans, precautionary reference levels have been proposed: 17β-estradiol: 0.001 μg/l; nonylphenol: 0.3 μg/l; bisphenol A: 0.01 μg/l. The indicated substances belong to a group of compounds that have a direct impact on human hormonal balance, causing neurological problems, disorders of sexual development, fertility, thyroid function, and increase the risk of cancer. It is necessary to protect people and secure drinking water.

The aim of the research was to develop a method for analysing endocrine-active compounds, with particular emphasis on: 17ß-Estradiol, Bisphenol A and Nonylphenol; selection of appropriate technical parameters of the method to obtain sufficient sensitivity and precision of the tests and determination of the analytical scope. Laboratory tests was carried out in the following research stages: collection and preparation of samples using the liquid-solid extraction technique and analysis using liquid chromatography with mass detection. The research method was optimized and the technical parameters necessary for the correct detection of the analysed compounds were established. Calibration was performed for each indicator and a series of analyses were performed for individual drinking water intakes in Krakow.

At the method optimisation stage, various protonating additives to the aqueous phase for each indicator with the same concentration (200ng/ml) were tested. The following detector responses were received:
- for BPA 5544: when using ammonium formate and 70662 when using ammonia
- for NPh: 1201 when using ammonium formate and 35891 when using ammonia
- for 17β-Estradiol: 224663 when using ammonium formate and 162608 when using formic acid.

A series of standard solutions were made for selected substances and the coefficient of linear determination R2 was obtained for BPA 0.7499; NPh 0.7559; 17βE 0.7327, blanks and control samples for BPA and NPh at a concentration of 200ng/ml. The following responses were obtained: 244ng/ml and 172ng/ml. For 17βE. The control test was performed at a level of 16ng/ml and a value of 18.05ng/ml was obtained.

The analytical tests were performed for one water intake in Krakow. Preliminary research showed that the correct research method was selected. Despite better responses for BPA and NPh using ammonia as an addition to the aqueous phase, ammonium formate was chosen due to the properties of the C18 chromatography column. The range of the calibration curve should be modified to improve the fit of the linear regression. Pilot tests of water samples from the ZUW in Krakow showed the absence of the tested substances in drinking water intakes.

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Keywords: endocrine-active compounds; 17β-estradiol; nonylphenol; bisphenol A

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Optimisation of green hydrogen production through nanomaterial-enhanced photoelectrochemical water splitting for sustainable development

The purpose of our article is to investigate the role of nanomaterial-enhanced photoelectrochemical (PEC) water splitting in the context of green hydrogen production and define the role of its utilisation. Our focus is on understanding how to optimise the performance of these nanomaterials and integrate them into scalable systems. Our research discusses the significance of utilising green nanomaterials in advancing the efficiency and sustainability of PEC water splitting for green hydrogen production. The elaboration is to answer the questions: 1) How to optimise the performance of these materials and integrate them into scalable systems? 2) What are the challenges and opportunities associated with integrating nanomaterials into large-scale PEC systems, all while maintaining cost-effectiveness and sustainability?" Therefore, we delve into the synthesis and characterisation of nanomaterials used in PEC water splitting, with a particular emphasis on their efficiency in harnessing solar energy for water splitting reactions. By enhancing the performance of the specific nanomaterials, such as semiconductor nanomaterials, we harness solar energy efficiently and ultimately contributing to a greener and more sustainable hydrogen production process. This research includes an introductory overview of the current state of nanomaterial-enhanced PEC water splitting for hydrogen production. The research methodology will be discussed, and the literature will be reviewed for sustainable hydrogen production. In the last section, we will present the recommendations that should be considered for enhancing the process of sustainable hydrogen production by leveraging nanomaterials within photoelectrochemical water splitting and for achieving sustainable development through this process.

Keywords: clean energy transition; green hydrogen; sustainable development; PEC water splitting

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Eco-friendly hydrogel technology for sustainable irrigation

The agricultural sector stands as one of the most rapidly expanding industries, driven by the escalating global demand for food and textiles to meet the needs of a growing world population. However, the use of water resources has become increasingly critical, especially in arid regions, as water scarcity contributes to soil degradation, desertification, and salinisation due to the dryness of soils especially in arid and desert regions, in addition to the fact that plants and soils have low water retention capacity which results in the use of vast amounts of water during irrigation. All this reduces soil water availability and productivity, crop growth, and water wastage.

The objective of this study is to prepare hydrogels based on both commercial and bio-sourced polysaccharides extracted by valorising waste materials such as those from the olive industry. These biobased hydrogels display significant advantages, including non-toxicity, ready availability, low production cost, biocompatibility, and biodegradability, with a huge water retention and absorption capacity without dissolution. In addition, it could be useful for wastewater treatment via an adsorption process or as a nutrient reservoir for slow-release fertilizer systems in agricultural uses. Nuclear magnetic resonance (NMR) Fourier Transform infrared spectroscopy (FTIR) confirms these materials' synthesis before studying their morphological, thermal, mechanical, and swelling properties.

Keywords: agriculture; biobased; polysaccharide; hydrogel; retention

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Possibilities of sharing water in multi-family buildings in cities for hydroponics - challenges and barriers

Due to the need to ensure the safety of city residents in times of climate change and uncertain geopolitical situation, it is extremely important to look for innovative and sustainable solutions to achieve this goal. Such solutions include the introduction of hydroponic crops supplied by water into multi-family buildings carried out as part of the SmartFood project. The article analysed the possibilities of implementing hydroponics in blocks in terms of the possibility of feeding them with water from different sources.

The introduction considers the reasons for undertaking research on the topic discussed and potential sources of water for hydroponics located in apartment blocks in cities. Research on the possibilities of feeding hydroponics with water was conducted based on the analysis of conditions occurring in selected locations, available scientific and technical literature and the professional experience of the research team in design. Moreover, the work carried out used the SWOT technique to analyse the possibility of sharing water in multi-family buildings in cities for the purposes of hydroponics. The strengths and weaknesses, as well as the opportunities and threats related to the introduction of sharing water from various sources were analysed in detail. On the basis of the work carried out, the most important limitations and barriers as well as the greatest challenges in this area were identified.

The research allowed for the assessment of the possibility of using various water sources to supplied hydroponics in multi-family buildings The identified barriers and challenges allowed for the identification of prospective directions for action on this solution.

Keywords: rainwater; food safety; water demand; climate change; sustainability

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Recent trends in emerging of grey water in India: an overview

Water being one of the most important resources in sustaining lives. Major factors like global warming, rapid urbanisation, increased overuse, and overconsumption of water have resulted in scarcity of water across the globe. It is an urgent need to look for sustainable methods that can account for most of the water use that replace the use of fresh water. One of the promising solutions in this regard is to implement technology that is based on the use of grey water. This research is based on the use of greywater which obtained from kitchen, bathing, and cleaning water with keeping out the toilet waste. Existing scientific and treatment process like physical treatment, chemical treatment, biological treatment, and combined treatment techniques has been discussed in detail. Centralised and decentralised methods are described and suggested for the wastewater treatment method to ensure proper management methods. Therefore, Reuse of greywater may lead to an increase in the resilience and adaptability of local water systems, a reduction in transit costs, and the attainment of reuse that is suitable for its intended use. Various technologies and treatment methods are used to potentially generate treated water that meets the permissible criteria for reuse in India. In conclusion, the advantages of greywater reuse are highlighted. These advantages include the possibility for water and energy savings, sustainable future, awareness of people, and social engagement are important factors which need to be considered in the reusing of the grey water in India for future.

Keywords: greywater treatment; greywater quality; water scarcity; water sustainability

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Sustainable Development
&
Circular Economy in Regions

Parallel session

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Analysis of factors influencing the circularity of plastic packaging waste recycling: a case study in the Baltic States

In 2020, 29.5 million tonnes of post-consumer plastics waste were collected in the EU. Around 40% of all plastic waste consists of packaging waste, and therefore it is one of the most important components of plastic waste. According to the Eurostat data, the amount of plastic packaging waste generated in the three Baltic countries (Lithuania, Latvia and Estonia) in 2020 was around 86, 46.7 and 53.6 thousand tonnes or 30.8, 24.6 and 40.3 kilograms per capita respectively.

In 2020, the waste management of post-consumer plastic packaging in the EU had the following trends – 46% was sent to recycling, 37% to energy recovery and 17% to landfill. The EU has set itself the goal of recycling of plastic packaging waste at the EU level by at least 50% by 2025 and 55% by 2030. The lack of recycling of plastic packaging waste results that too many finite resources are being wasted instead of being returned to the circular economy. In this case particular attention is paid to the packaging waste management.

The results of waste morphological investigations carried out in three municipalities of the Baltic States (Kaunas, Daugavpils and Tallinn) in 2023 showed that the plastic content of separately collected plastic waste is up to 67%, while the plastic content of mixed municipal waste is up to 40%. In terms of polymer types, LD-PE, HD-PE and PP are the predominant plastic wastes. The recycling rate of plastic packaging waste in all Baltic countries is likely to be up to 45%, which leaves it out of line with the EU's recycling targets for plastic packaging.

For improving the management and the recycling of plastic packaging waste, the following observations of investigation were drawn:

- ✓ Plastics packaging waste recycling rates are higher when collected separately compared to mixed waste collection schemes (may varied around 13-80 times).
- ✓ Due to the different physicochemical properties of plastic polymers, waste from different plastics should be collected separately to increase the potential recycling rate.
- ✓ Implementation of new recycling methods for plastic waste to improve the recycling of pure and contaminated plastic waste.
- ✓ Improvement of the waste sorting line in waste treatment facilities towards higher separation efficiency for plastics of different polymers.

Further research is needed to improve the plastic waste management scheme and implement technical solutions.

Keywords: circular economy; plastic waste; sustainable management and use of raw material

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Circular Economy trends in the United Kingdom based on mixed-methods analytics on LinkedIn-mined data

The Circular Economy (CE) is an economic model that can significantly contribute to sustainability, environmental preservation, and socioeconomic growth. This study is a joint research of two different works on mapping CE-related topics and trends in the UK. For this reason, we have exploited the LinkedIn social media platform to acquire business-oriented data from companies' public profiles. Our datasets included companies with "Circular Economy" and 8 of the most essential construction materials (iron, cement, plastic, sand, glass, wood, aluminium, and steel). Further, we also provide an evolutionary overview of the CE-related companies and job posts for the past two years in a panel data format. The findings indicate a significant increase in companies that shifted their interest towards CE alongside the essential diversity of topics around the examined search terms. More precisely, we have deployed LDA (Latent Dirichlet Allocation) modelling to investigate the concepts and strategies in-depth. Among the most essential outcomes of this research has been validating the LinkedIn platform as a valuable and intuitive data source for business analytics. The findings suggest a higher contribution of steel and iron to the construction sector in terms of circular economy. Additionally, the distribution of companies according to the industry sectors indicates a strong orientation towards higher-level environmental services such as design, IT, consulting, and management. Overall, this methodology offers a significant head start in business analytics and decision-making activities as it helps shape a complete and robust picture of the studied topics.

Keywords: circular economy; linkedIn; LDA; fashion; construction

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Innovative approaches to wastewater management and recycling: a case study of Benin, Kenya, Zambia in pursuit of sustainable solutions in the context of Green Deal

One in three people in the African region suffers from water scarcity, this situation is getting worse as a result of population growth. Poor wastewater treatment exacerbates the problem, as only 10% of wastewater in Africa is estimated to be treated before being released into the environment. The major wastewater sources in Africa are agricultural, mining, domestic, and industrial effluents, which include BOD, COD, TSS, NH 4-N, and T-P, heavy metals (like Pb2+, Zn^{2+}, Cu2+), organic compounds, and fecal coliforms.

Notably, the most widely used treatment method in Kenya is the application of single or combined constructed wetlands and conventional wastewater treatment systems. Whereas, wastewater in Zambia is mostly treated by the use of aerated stabilisation ponds. In the case of Benin, the lagoon systems are applied in organic wastewater treatment, while simple and macrophyte lagoon systems are used to treat and recycle domestic wastewater.

The results show that the treated wastewater is low quality, containing significant levels of BOD, COD, TSS, phosphorus, lead, and nitrate. It also exceeded the established regulatory discharge standards, affirming that the treatment methods were not fully effective. The nutrients are not entirely removed by the treatment procedures currently in use. In conclusion, the paper review more cost-effective, sustainable, and innovative technologies to improve wastewater management in Africa, such as the application of iron oxides, zeolites, biochar filters, or membranes. Such an approach will result in lowering environmental pressures in urbanized and rural areas.

Keywords: wastewater treatment; water quality; environment; pollution; Africa

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Transformative capacity building for Green Deal by systematic use of urban living labs

This article aims to introduce the concept of Urban Living Lab (ULL) as a method for urban transformative capacity building in the water-food-energy nexus. Since the beginning of 2000s, the Urban Living Labs (ULLs) are being researched and examined as experimental settings that bring together various stakeholders, such as citizens, researchers, businesses, and policymakers, to co-create and test innovative solutions for urban developments. They offer a collaborative and participatory approach to urban solutions that engages and empowers local communities and fosters a culture of shared foresight process and mutual learning. In the context of local development, the ULLs can serve as a powerful tool for building the Urban Transformative Capacities (UTC) by providing a platform for local actors to develop their skills, knowledge, and networks for intersectoral cooperation, and by creating opportunities for experimentation and experiential learning. The case of Alytus, Lithuania, is an interesting example of how the Urban Living Labs can be used to drive local development in the Green Deal context. Alytus is a mid-sized city in Lithuania, Northern Europe, that has faced a range of typical to region social, geopolitical, economic, and environmental challenges in recent years, including declining population, high unemployment, and deteriorating public spaces. The aim of this study was to analyse the perspective of implementation of European policies and methodologies presented in the Urban Europe Programme if applied to the search of transformative capacities' building for better city co-governance. In this respect, an urban transformative capacity building were analysed in the water-food-energy nexus in Alytus city.

Keywords: urban transformative capacity; urban living lab; co-creation.

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Urban garden in view of implementation the Green Deal strategy - study of the potential and development of urban gardening strategy

Urban gardens are part of the urban greenery system and perform the functions of production, recreation and ecosystem services. Research is presented on the social capital of recognising barriers and potential for urban gardening and urban agriculture development strategies. Conclusions of inventory work and built environment impact analyses are also presented. In conclusion, recommendations for a model of spatial, social and environmental elements of urban gardening and urban farming are indicated. The main aim is research of urban gardens as a key component of the strategic for sustainable urban development, from an interdisciplinary approach. The objectives: to identify needs, problems and opportunities concerning urban garden, the stakeholders' capacity building in terms of green governance for food production and consumption in cities to drive citizens' capacity building for the involvement in sustainable urban development experiences; the impact of the implementation of urban garden experiences in their social, cultural and environmental dimensions; multi-criteria framework to support decision-making in the location of urban gardens and agroforestry plots. Local food production and management models for urban gardens, food production and consumption are analysed. The results of a study of community capacity building are presented. The issue of urban gardens in social, cultural and environmental dimensions for the development of multi-criteria guidelines to support decision-making on the location of urban gardens is explored. Conclusions and recommendations presented urban gardens as a strategic element of sustainable urban development in social, environmental, spatial and urban design aspects.

Keywords: urban gardens; urban farms; urban design; sustainable development; green deal strategy

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Topic modelling on luxury fashion companies in the United Kingdom according to their LinkedIn profiles

The fashion industry has always been a critical factor in societal evolution and economic growth. A side effect though is that it has developed into a massive industry sector responsible for major polluting activities, globally. For this reason, extensive research on topics like fashion-related sustainable practices or circular business models has already been conducted. In this work, we aim to deploy a novel approach to this industry sector monitoring from the perspective of social-media available data and more specifically the LinkedIn platform. As LinkedIn is probably the most business-focused online networking platform, there is a vast amount of data available for both qualitative and quantitative analysis. Thus, we conducted research on 1,115 business profiles in the fashion and textiles industry sectors containing the term “luxury”. Among the main findings of this study, we highlight the diverse topics found in the description section of our dataset using Latent Dirichlet Allocation (LDA), indicating which are the most important five drivers of luxury fashion in the United Kingdom, including (1) Artful Creations in Fashion, (2) Time-Honoured Craftsmanship, (3) The Art of style and design, (4) The Pinnacle of Retail Excellence, and (5) A Personalised Style Experience. Further, we look into the sustainable and circular mentions among the examined profiles with the analysis indicating a significantly higher frequency of sustainability-related terms within the text corpus. Our study not only provides a glimpse into the present dynamics of the UK luxury fashion industry but also establishes a foundation for future research. Our research acts as a valuable reference for industry professionals, policymakers, and scholars, shaping conversations, influencing decisions, and fostering innovations within the landscape of luxury fashion.

Keywords: luxury fashion; linkedIn; circular economy; sustainability; LDA

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Sustainable PV modules recycling: maximising resource efficiency

As the use of PV modules continues to grow, so does the need for responsible end-of-life management. Recycling solar panels is the key to reducing electronic waste and preserving valuable materials. Several methods can be employed to achieve maximum recycling. Thermal Treatment is the first method that is more optimal in saving resources. High-temperature processes like incineration or pyrolysis can break down solar panels, generating energy while recovering essential materials like silicon, glass, copper and other rarer chemical elements. The second method for PV module recycling is mechanical separation. Some recycling plants remove the aluminium frame and shred all the glass, silicon and other metals into a mixture that can be sold for building materials or other industrial applications. Both methods use chemical components to extract valuable metals from panels. These recovered materials find new life in various applications. Recycling PV modules conserves resources and reduces the environmental footprint of panel disposal. Sustainable practices support a circular economy in the solar industry, promoting long-term environmental and economic sustainability. Embracing these recycling methods is a crucial step in ensuring the continued growth of solar energy without compromising our environment. By implementing responsible end-of-life practices, we can make solar power more sustainable for future generations.

Keywords: PV modules; recycling; methods; process; circular resource

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Waste, Wastewater and Innovation

Parallel session

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Effect of microwave and ultrasonic pre-treatments on anaerobic co-digestion of orange wastes and municipal sewage sludge

Despite significant technological progress in a waste management, the application of many residues in the anaerobic digestion process is still a challenge. This group includes orange wastes. In this study, the influence of microwave and ultrasonic pre-treatments on anaerobic co-digestion of orange wastes and municipal sewage sludge was evaluated. The first part of study included the selection of optimal pre-treatment conditions in terms of biodegradability and the inhibitors formation. In the case of microwave strategy, energy input of 900 W and time of 10 min were adopted as the most beneficial conditions. In turn, ultrasonic conditions were chosen as frequency of 26 kHz, power input of 19 kW and time of 20 min. Subsequently, the anaerobic co-digestion experiments were performed under mesophilic conditions in batch reactors. Additionally, mono-digestion of SS was conducted as a control. As compared to SS mono-digestion, the enhanced both biogas and methane productions were found only in the case of US pre-treatment. Therein, the biogas and methane production reached the values of 548 and 346 mL/gVS, respectively. Additionally in this case, improved organic compounds removal was observed as compared to the control. Regarding MW pre-treatment, comparable results in terms of both biogas and methane productions to control were achieved.

Keywords: anaerobic co-digestion; biogas production; sewage sludge pre-treatment; orange peel

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Microplastics in sewage sludge from municipal wastewater treatment plants

Plastic pollution is currently one of the main challenges in environmental protection. One of the significant problems is the presence of microplastics (MPs) in municipal wastewater. MPs are microscopic plastic particles whose size does not exceed 5 mm.
In municipal WWTPs, MPs accumulate in sewage sludge. The presence of MPs in sewage sludge when used in agriculture poses a serious threat to the environment. Some MPs may migrate from sediments to surface waters via surface runoff, thus increasing the problem of MPs occurrence in the natural environment.

This work focuses on determining the content and characterisation of MPs in dewatered sewage sludge at a large municipal wastewater treatment plant (WWTP). The isolated particles were characterized physically, using a stereoscope, analysing their morphological and chemical characteristics (infrared spectroscopy with Fourier transform), determining the type of polymers.

The MPs content in sewage sludge is significant. The analysis of the sizes of isolated MPs shows that the dominant fraction of MPs in the investigated sewage sludge consists of particles with a size between 1mm and 0.5mm. Due to the shape of isolated MPs, they are divided into: foils, fragments, foams, granules and fibers. The analysis showed that over 50% of all particles were synthetic fibers. Among all MPs, 12 different colors were identified. Chemical analysis revealed that the sludge contained 20 different polymers, 26% of which were identified as poly(ethylene terephthalate) particles.

Research focusing on the content of MPs in sewage sludge will allow us to better understand the contribution of municipal WWTPs to environmental pollution with MPs.

Keywords: microplastic; wastewater treatment plant; sewage sludge

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Potential of biochar-based column filtration systems for wastewater treatment: effects of biochar concentration

Wastewater treatment for water reuse has received considerable attention owing to water resource shortage. One of the most effective wastewater treatment methods involves the use of column filtration systems (CFS). Biochar-based column filtration systems (BCFS) for wastewater treatment have gained attention in the last decade. In this study, decanted wastewater was treated by using a biochar-based column filtration system. The biochar using in this study was produced from exhausted olive pomace at a temperature of 590°C and maintained for a residence time of 2h with a heating rate of 10°C/min. Four BCFS were constructed on the basis of the volume ratio of biochar in common sand (0%, 10%, 25%, and 50%) to explore the influence of biochar dosage on the treatment performance. The results showed that the biochar added to BCFS provided higher removal efficiencies for ammonium (54.6%–75.2%), COD (44.7%-56.3%), total phosphorus (36.6%-42.9%), orthophosphate (37.7%-43.1%), and total suspended solids (84.7%-93.1%). The BCFS with 10% biochar showed the best removal performance toward the NH_4^+ (75.2%), COD (56.3%), TP (42.9), PO_4^{3-} (43.1), and TSS (93.1%), compared with control column filtration system (CCFS) for ammonium (53.6%), COD (32.3%), total phosphorus (27.3%), orthophosphate (31.9%), and total suspended solids (79.2%) respectively. Moreover, this performance in eliminating these pollutants is accompanied by a release of nitrate, nitrite, and sulphate pollutants by all CFS.
Based on this preliminary study, the efficiency of BCFS in removing pollutant from wastewater is optimal with the small amount of biochar (10%).

Keywords: biochar; wastewater treatment; column filtration systems

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Biopolymers derived advanced materials for wastewater treatment

Development of materials derived from natural resources is a growing trend driven by concerns about environmental sustainability, resource depletion, and the desire to reduce the carbon footprint associated with the production and use of synthetic materials. Referring to their natural source, these materials are named biobased materials because they are from biopolymers which are derived from living organisms namely plants and animals. Cellulose is the most abundant natural biopolymer among others. Biopolymers have properties such as renewability, biodegradability, tunable surface, cost and non-toxicity hence considered as promising alternative materials. However, the inert nature of the derived materials results in limited applications. A viable solution lies in employing surface modifications to enhance the physicochemical and biological properties for effective use. The purpose of this work is to enhance the potential of natural derived materials via surface modification by introducing new functional moities for wastewater treatment. Therefore, lignocellulosic fibers from Giant reed plant were functionalized through phosphorylation and exhibited improved adsorption capacity towards cationic industrial dyes and copper ions. The removal efficiency of MB after phosphorylation of giant reed fibers for copper ions, MB, BB41, BR 46, and BY 28 reached 80.90%, 99.58%, 99.30%, 99.26%, and 94.92%, respectively. The resulted adsorption capacities are 328.76 mg/g, 373.94 mg/g, 493.65 mg/g, 352.21 mg/g, and 364.01 mg/g for copper ions, MB, BB41, BR 46, and BY 28 respectively. It is crucial to upgrade these materials and turn them into more sustainable shapes capable of being employed at large scale.

Keywords: biopolymers; lignocellulose; functionalisation; wastewater; adsorption capacity

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Using microalgae isolated from extreme conditions for phenolic compound removal: a promising method for treating olive mill wastewater

The potential of microalgae as a sustainable solution to remove phenolic compounds is substantial. Industrial mill wastewater often contained phenol. This study focuses explicitly on isolating microalgae, particularly diatoms, from extreme environments. Its goal is to explore their effectiveness in treating industrial wastewater, specifically the olive oil industry. The research involved isolating various diatom strains and evaluating their ability to eliminate phenol, aiming to address incomplete treatment challenges related to phenolic compound concentrations ranging from 50 to 250 mg/L. To assess their response under stress, chlorophyll fluorescence was measured. Our findings revealed diverse reactions among diatom strains when exposed to phenol concentrations from 50 mg/l to 250 mg/l; the highest phenol elimination percentage, ranging from 75.5% to 99%, is remarkable at the 50 mg/L concentration level.

Notably, most strains showcased promising phenol removal rates exceeding 50%. This study illuminates the potential of isolated diatom strains in effectively eliminating phenol, emphasising their significance as powerful microorganisms in wastewater treatment processes.

Keywords: microalgae; diatoms; extreme environments; phenol elimination; wastewater treatment

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Innovative green nanoparticle synthesis and phenol elimination from olive oil mill wastewater

Olive oil mill wastewater (OMWW) represents a major environmental problem due to its high organic load and high concentration of phenolic compounds.

This study proposes a new approach for the synthesis of nanoparticles and their application in environmental remediation. Specifically, copper oxide (CuO) nanoparticles were produced using the cell lysate supernatant microalgae and then cross-linked with sodium alginate (SA) to form CuO-SA beads. To characterize these CuO-SA beads, various analytical techniques were employed, including scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), Fourier transform infrared spectroscopy (FTIR) and X-ray diffractometer (XRD).

Phenol adsorption experiments were carried out in a fixed-bed column to assess the adsorption capacity of CuO-SA beads. The results revealed a phenol adsorption capacity of 314 mg g^{-1} of material, which was achieved with an initial phenol concentration of 4000 mg L^{-1}.

Keywords: adsorption; nanoparticle synthesis; olive oil mill wastewater; phenol

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Scaling-up electro-oxidation treatment for efficient phenol removal from petroleum refinery wastewater: a pilot-scale study developed from lab-scale experiments

This paper presents the successful application of a pilot-scale electro-oxidation treatment unit (EOX) for the removal of phenol from petroleum refinery wastewater. The treatment unit was developed from lab-scale experiments and optimized for efficient and cost-effective removal of phenol. The EOX consisted of ten cylindrical reactors with a graphite anode and a stainless-steel cathode and was operated at two different wastewater streams in oil refinery factory. The efficiency of the treatment was evaluated by monitoring the removal of phenol as well as chemical oxygen demand (COD) , biochemical oxygen demand (BOD) and oil from the wastewater. The results showed that EOX was highly effective in removing phenol from the wastewater, with a removal efficiency of up to 99,9 % achieved at an applied voltage of 10 V and a reaction time of 20 minutes. In addition, the paper investigates the effect of various operating parameters, such as current density, and energy consumption. The results showed to be in agreement with the results of lab-scale study. Also, analysis of accumulated solids on the electrode showed that most of these solids composition is organic form. Overall, this study demonstrates the successful upscaling of an electro-oxidation treatment unit from lab-scale to pilot-scale, and its potential as a cost-effective and efficient treatment method for phenol removal from petroleum refinery wastewater.

Keywords: electro-oxidation; pilot-scale; phenol; wastewater; energy consumption

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Sustainable treatment of textile processing wastewater in economically constrained environments: leveraging calcium hypochlorite oxidation coupled with sand filtration using recycled blast furnace iron slag for repurposing treated effluent in wet processing

The textile industry plays a vital role in Bangladesh's economy, serving as the country's largest foreign exchange earner and employing more than four million people. However, the unplanned concentration of textile industries has led to adverse environmental impacts, particularly through the unregulated discharge of untreated wastewater. Compliance issues arise due to the high treatment costs associated with expensive imported chemicals and energy-intensive systems. In the pursuit of a sustainable solution, a pilot-scale technology development project was initiated at an operational textile wastewater treatment plant. The process involved the chemical oxidation of treated wastewater using calcium hypochlorite, followed by rapid sand filtration with the assistance of waste blast furnace iron slag. This approach resulted in the complete removal of color and further reductions of 95% for COD, 93% for TDS, and 89% for TSS, ensuring that the treated water met Bangladesh's discharge standards. Consequently, this water can be reused in textile wet processes. Fabrics dyed with the recycled water exhibited comparable color fastness in both dry and wet conditions. The developed tertiary treatment process, relying on locally available resources and technology within the regional supply chain, holds the potential to serve as a sustainable wastewater treatment option for textile industries in resource-challenged economies. This approach aligns with the objectives of sustainable development by embracing circular economy principles.

Keywords: Bangladesh; blast furnace; iron slag; supply chain; sustainable development

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Evaluation of the impact of enzymatic disintegration on the anaerobic digestion of sewage sludge

Anaerobic digestion of sewage sludge is a valuable process in the sludge management of wastewater treatment plants, reducing sludge volume, destroying pathogenic organisms, and producing high-energy biogas. In this process, the availability of organic matter to microorganisms is crucial. Most organic compounds in cells and many complex macromolecules are difficult to access. The disintegration process breaks down these cells, releasing intracellular fluids and increasing their availability for further stabilisation processes. This process leads to accelerated hydrolysis (anaerobic decomposition limiting factor) by releasing enzymes contained in the cells. As a result, the decomposition of organic substances increases, intensifying biogas production and reducing the amount of sludge.

Technological development of the intensification of anaerobic digestion of sewage sludge leads to difficulties in selecting the appropriate disintegration method. The main selection criteria are the direct and technological effects of disintegration. The direct effects include hydrolysis and particle fragmentation by determination of disintegration indicators, such as COD soluble, sludge dewaterability, respiratory activity, protein content, floc structure and size. The technological effects include increased biogas production and methane content, reduced sludge volume and improved dewaterability.

The aim of the research was to test the impact of enzymatic disintegration on biogas production and dewaterability of sewage sludge. The results showed an increase in biogas production of about 5%. However, a slight effect on the sludge's susceptibility to dewatering was observed; dewaterability improved by about 2%. In summary, disintegration during anaerobic digestion is a crucial process that contributes to the optimal use of organic materials, generating both environmental and energy benefits.

Keywords: enzymatic disintegration; anaerobic digestion process; biogas; dewaterability

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Sustainability

Parallel session

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Hydrothermal carbonisation of invasive plants as a tool of safe utilisation and valorisation of biomass

Spreading of invasive plants is one of significant environmental problems, considering reduction of biological diversity, adverse impacts on agriculture, forestry, recreation possibilities as well as direct risks to human and animal health. One of key problems limiting invasive plant eradication efficiency is plant biomass safe utilisation possibilities. Hydrothermal carbonisation (processing of plant biomass in aqueous environment at 160 – 250 C, for 2 till 24 hrs in presence of catalyst) can be considered as a promising biomass treatment technology as during thermal treatment plant propagation possibilities are destroyed. During hydrothermal carbonisation hydrochar (after activation biochar) as well as artificial humic substances are formed as products with high application potential in different technologies. The yield of hydrochar/humic substances depends on the process conditions and type of catalyst. Characterisation of carbonaceous materials demonstrates high porosity, good sorption capacity in respect to metals ions, as well as organic substances. In comparison with composting, hydrothermal carbonisation can be evaluated as climate neutral approach, but biochar obtained as a result of pyrolysis of plans biomass or hydrochar demonstrates high carbon capture (CO_2 sorption) capacity. Artificial humic substances demonstrate similarity to natural humic matter and can find application in agriculture.

Keywords: invasive plants; hydrothermal carbonisation; hydrochar; humic substances

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Reducing the impact on global warming potential during biodegradable waste management through industrial symbiosis methods: a case study in Jonava district (Lithuania)

Lithuania has committed itself, together with the EU and its member states, to reduce greenhouse gas emissions (GHG) by at least 55% compared to 1990 by 2030. The purpose of this study is to assess opportunities to minimize impact on Global Warming Potential (GWP) due to GHG from management of biodegradable waste (BDW) at the regional level by applying methods of Industrial Symbiosis.

In the analyzed Municipality of Jonava district (area - 944 m^2, population – 41.6 thousand), the main flow of BDW were identified: green waste collected in public areas; BDW from mixed municipal waste (MW); sewages sludge, which is characterized by a high nitrogen content, since part of the wastewater comes from a nitrogen fertilizer production plant; biofuel ash. Total annual amount of this waste is approx. 4.4 thousand tons. Most of them are transported for centralize processing in Kaunas. Only sludge is processed at the facility (it is stored for more than 1 year and transferred to fertilize energy fields). The impact to GWP was determined by assessing material and energy flows. Analyzed activities annually generate more than 730 tons of CO_{2e}.

The greatest potential for reducing GHG comes from changing sewage sludge treatment technology. The study proposes producing higher quality compost (soil improver) from sewage sludge with other carbon-rich BDW at existing facilities after their modernisation. As a result, the impact to GWP will be reduced by more than 65%.

The main results of the analysis, as well as composting experiment, will be presented at the conference.

Keywords: biodegradable waste; industrial symbiosis; global warming potential

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Climate change and strategies toward climate neutrality

This comprehensive study delves into the objectives, findings, and conclusions of research on climate change and the strategies required to achieve climate neutrality. The primary aim of this study is to assess the current state of climate change and explore effective approaches to attaining climate neutrality.

Climate change poses a complex and urgent global challenge, with profound implications for the environment, society, and the economy. To achieve climate neutrality, a holistic approach is necessary, encompassing various sectors such as energy, transportation, agriculture, and industry.

Through an extensive literature review, analysis of existing climate policies and initiatives, and examination of successful case studies, research highlights key strategies for mitigating climate change. These include transitioning to renewable energy sources, enhancing energy efficiency, promoting sustainable land use practices, and adopting circular economy principles. Additionally, international collaboration, policy coherence, and public engagement are crucial for achieving climate neutrality.

Based on analysis, several key conclusions emerge. Firstly, a multifaceted approach that combines technological advancements, policy frameworks, and behavioral changes is essential for successful climate mitigation. Secondly, the transition to a climate-neutral society must prioritize a just and equitable distribution of resources and benefits. Lastly, continuous monitoring, evaluation, and adaptation of strategies are necessary to ensure long-term sustainability in the face of evolving climate challenges.

Keywords: climate; climate neutrality; climate efficiency; global challenges; environment

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The integration of renewable solar energy systems in net-zero energy buildings under Mediterranean climate

From an ecological perspective, sustainability alternatives require, on the one hand, the reduction of energy consumption and, on the other hand, taking advantage of so-called renewable primary energies such as: solar, wind, hydraulic, geothermal energy., biomass, etc. Among these so-called clean energy resources, solar energy is available at all levels of the earth.

Through this study, we will try to highlight the importance and effectiveness of solar energy as a relevant alternative to integrate into the net zero energy architectural design process that aims to use solar energy to power the energy needs of a building while ensuring that the latter only consumes the energy it produces. The goal is to minimize dependence on external energy sources and maximize the use of renewable energy sources to obtain a self-sufficient, net-zero energy building. The aim of this research is firstly to assess the feasibility and effectiveness of integrating these systems, and secondly to evaluate the economic and environmental benefits of using them.

This paper carried out an experimental study on the integration of a photovoltaic system within a cultural centre. The objective is to study the impact of this installation on the building's annual energy consumption, and the possibility of making the building a zero-energy building by installing a photovoltaic system. This was done using Retscreen clean energy awareness software. According to the results, the photovoltaic system integrated into the project generates 961,847.20 kWh of electricity per year, covering 74.33% of the building's annual electricity consumption. This reduces the annual electricity bill by 25%.

Keywords: ecological architecture; solar energy; renewable energy; energy efficiency

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Mineral waste valorisation for sustainable thermoplastic composites with antimicrobial properties

The extraction, screening, and segmentation processes in natural quarries often generate a substantial volume of waste, which is typically inert and ends up in landfills. Urgent attention is required to seek sustainable solutions for the valorisation of these mineral wastes by creating innovative products with increased added value and active functionalities. This study investigated the feasibility of utilising mineral waste derived from a local Azorean Quarry to develop advanced active thermoplastic ecocomposites. Multiple formulations were examined to identify achievable production parameters. Furthermore, an antibacterial agent was incorporated, and its effectiveness was evaluated. The mechanical properties, thermal conductivity, wettability, and density of the thermoplastic ecocomposites were assessed, along with its thermoformability. The results obtained in this study have indicated the potential for the sustainable development of advanced and active thermoplastic ecocomposites, utilising mineral waste from quarry operations. This approach opens up new opportunities for mineral waste valorisation and the creation of novel recyclable products with adequate mechanical properties. This research highlights a promising avenue for addressing the environmental challenges associated with mineral waste from quarries. By repurposing these waste materials into active thermoplastic ecocomposites, this study contributes to sustainable practices and the development of economically valuable and eco-friendly products.

Keywords: waste valorisation; thermoplastic composite; antimicrobial

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Methodological crossroads in microplastic research: bridging gaps and unveiling challenges

Microplastics (MPs) constitute a complex suite of contaminants, encompassing diverse polymers, sizes, morphologies, and associated chemicals. Detected in various environmental compartments such as aquatic environments, sediments, and drinking water, their pervasive presence prompts concerns about potential impacts on aquatic ecosystems.

This study reviews existing literature on MP toxicity, emphasising the lack of consensus on categorisation, standardized methods, and the need for long-term impact assessments. Examining data from the Toxicity of Microplastics Explorer (ToMEx), we identify gaps and challenges, suggesting improvements in study design and the development of open databases for collaboration.

Toxicity studies commonly report MP as mass or particle count per volume of water, with an emerging trend toward dual reporting for comparative analysis. MPs are typically assessed based on particle size, shape, and polymer type, revealing a prevalence of spheres, fragments, and fibres. The most frequently studied polymer types, polystyrene and polyethylene, align with environmental observations, but the limited representation of polypropylene in effect studies highlights a gap.

While substantial progress has been made, the study calls for enhanced reporting standards, high-quality toxicity tests, and a focus on long-term effects to understand the ecological implications of microplastic contamination comprehensively. The findings aim to guide future research, fostering reliable and valuable contributions for effective environmental risk assessment.

Keywords: microplastic; toxicity; environmental risk assessment

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Revolutionising building materials: assessing the superiority of novel geopolymer bricks in sustainable construction

In this pioneering study, we thoroughly evaluate the effectiveness of novel geopolymer bricks as a sustainable and environmentally friendly alternative to traditional cement-based bricks. Our research encompasses a wide array of tests, encompassing compressive strength, thermal conductivity, and environmental impact assessments. The results of these analyses demonstrate a remarkable 30% increase in compressive strength when compared to conventional cement bricks, along with a 15% reduction in thermal conductivity, indicating enhanced energy efficiency in building construction. Additionally, our examination of the environmental impact reveals a significant reduction in carbon emissions, with the geopolymer bricks outperforming cement-based bricks by up to 40%. These findings underscore the considerable potential of these innovative geopolymer bricks to address the dual challenges of sustainability and construction material performance.

Keywords: geopolymer; bricks; sustainability; construction; innovation

Acknowledgments: NITTTR Chandigarh for providing research facility.

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Simultaneous removal of carbamazepine, diclofenac, ibuprofen and sulfamethoxazole from water using selected advanced oxidation processes - opportunities and challenges

The presence of pharmaceutical compounds in wastewater poses a significant environmental challenge, necessitating effective treatment strategies. This study explores the simultaneous removal of four commonly found pharmaceuticals, namely carbamazepine, diclofenac, ibuprofen, and sulfamethoxazole, from water using various advanced oxidation processes (AOPs). Ozonation, UV treatment, and photocatalysis with titanium dioxide (TiO_2) were investigated both individually and in combination to assess their efficacy.

The experimental design involved varying pH, reaction time, and TiO2 dosage to optimize the removal efficiency for each pharmaceutical. The results demonstrated that each AOP exhibited different degrees of removal for the target compounds. Ozonation showed promising results for diclofenac, while UV treatment was effective for ibuprofen. Photocatalysis with TiO_2 demonstrated varied success across the pharmaceuticals, depending on the operating conditions.

Despite the differences in removal efficiencies, the study identifies the potential for developing a unified treatment approach that efficiently removes all four pharmaceuticals simultaneously. The challenges and opportunities associated with the combined processes are discussed, emphasising the need for further optimisation and exploration of reaction conditions. This research contributes valuable insights into the development of comprehensive and sustainable strategies for the simultaneous removal of multiple pharmaceuticals from wastewater using advanced oxidation processes.

Keywords: pharmaceuticals removal; advanced oxidation process; pharmaceuticals

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Bioeconomy

Parallel session

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Bioremediation and bioeconomy - a circular economy approach

The objective of this key lecture is to present „innovative and cost-effective solutions to decontaminate polluted environments, including usage of contaminated land and wastewater for generation of useful products to boost bioeconomy and circular economy". Bioremediation and Bioeconomy: A Circular Economy Approach provides a common platform for scientists from various backgrounds to find sustainable solutions to environmental issues, including remediation of emerging pollutants and usage of contaminated land and wastewater for bioproducts such as natural fibers, biocomposites, and fuels to boost the economy. The need for transitioning to a sustainable use of natural resources is now more evident than ever as industrialisation and pollution are global phenomena. To achieve this, Biodiversity is used as raw material for environmental decontamination, and the produce from bioremediation is valorized/ converted into useful products such as fuel, biocomposites etc. This approach has grown phenomenally in recent years, having emerged less than 3 decades ago. The increase in volume of contaminated organic and inorganic substrates (water, soil, and air) increased the scope of this subject phenomenally. The bottlenecks and solutions to the existing limitations in field scale are also discussed.

Keywords: bioeconomy; bioresources; circular economy; co-generation; contaminated substrates; natural resources; value addition products; value chain

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Development of a closed system model for sea buckthorn

Biomass is the basis of food system and future bioeconomy. To produce food, feed and biomaterials, humans harvest biomass from agroecosystems as well as natural ecosystems. More and more biomass is harvested every year, leading to various environmental issues, such as land-use change, biodiversity loss, etc. The need to transform the economy to avoid exceeding the Earth's biophysical limit is widely recognized, and a circular bioeconomy is one of the ways to achieve this. It intends to unlock the full potential of all types of sustainably sourced biomass including residual biomasses, such as crop residues, industrial side-streams, and food waste. The resulting bio-based product portfolio consists of a wide spectrum of value-added products, not just food and feed, but also bio-based chemicals, materials, health-promoting products (e.g. pharmaceuticals) and bio-based fuels.

The nutritional richness, versatility, sustainability in cultivation, low input requirements, waste utilisation potential, and scope for innovation make sea buckthorn a suitable and valuable plant within the framework of a circular bioeconomy. As a goal of the research, conceptual closed system model was developed for sea buckthorn farm, which includes plantations and processing. The model is based on an example of the real farm, and it additionally uses literature-based considerations, and results of laboratory tests of extracts production. Buckthorn berries, branches and leaves in a cascading sequence are transformed into a variety of food and pharmaceutical products; the remnants are suitable for fodder production, and they also rejuvenate soil health. A closed cycle is achieved with virtually no wastage.

Keywords: sea buckthorn; circular bioeconomy; closed system model

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Management and rational use of land as a natural asset

Agricultural land is a natural asset and it should be taken into account that the change of landscapes from natural vegetation to any other use can lead to loss of fertility as a source of ecosystem services. The purpose of our study was to substantiate the relevance of management and rational use of land as a natural asset. As a tool, we considered crop rotation planning that will help reprioritize crop selection, increase fertility, and reduce carbon emissions. The introduction of carbon crop rotations as a tool for soil quality management should contribute to a change in priorities in the choice of agricultural crops, and as a result, an increase in fertility and an increase in carbon sequestration. To substantiate this idea, we have conducted a study of the relationship between the yield of various crops and the absorption/release of carbon dioxide. We have studied this connection and created the model of dependence of CO2 uptake/emission on the yield of different crops shows that the ability to release carbon by plant residues of different agricultural crops has both a direct and inverse relationship with the yield of various crops. We have developed a decision-making model for planning the costs of an enterprise, subject to planning for environmental risks. Thus, the introduction of carbon crop rotations should help change priorities in the choice of agricultural crops, increase fertility, and reduce carbon emissions.

Keywords: natural asset; ecosystem services; carbon sequestration; soil fertility; carbon crop rotations

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Integrating multivariate statistical analysis and geospatial method to study the sediment contamination in chao phraya river network

This research investigated the spatial variations of heavy metals and nutrients in the sediment of the Great Chao Phraya River network of Thailand using the multivariate statistical analysis and geospatial methods and explored their possible integration, along with the detail analysis using geographically weighted regression (GWR). Extensive explanatory variables, including land use type and topographic, socio-economic, and meteorological indicators were utilized in the geospatial regressions of river sediment contaminants at the sub-catchment scale. The performance of GWR in explaining the spatiality of selected contaminants using single and multiple predictors was compared and discussed, and a suitable approach was recommended for sediment study. In general, Principal Component Analysis (PCA) results revealed Cr and Ni potentially sourced from natural or lithogenic origin, Pb, Cd and Zn from urbanisation and industrialisation, Hg and As from the mining and industries, nutrients (TC, TN and TP) from domestic activities and agriculture. GWR model is advantageous over Ordinary Least Square Regression in explaining the spatial variation of sediment contaminants demonstrated by its higher R^2 (over 2-fold time OLS R^2), lower Akaike Information Criterion, and reduced spatial autocorrelation problem. Multivariate GWR model was with higher local explanatory power and performance than univariate GWR model. The performance of GWR model increased with the increasing level of urbanisation i.e., the variability of contamination was explained well in the developed watershed that shows GWR is suitable in developed watersheds. It is recommended to adopt the integration approach and combine the applications of univariate and multivariate GWRs to understand the effects of selected explanatory predictors on sediment contaminations from different perspectives.

Keywords: geographically weighted regression; ordinary least square; sediment nutrients and heavy metals; single and multiple explanatory predictors; local spatial variation

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Removal of cationic and anionic dyes utilising brassica oleracea (cabbage) powder from the aquatic environment

Brassica Oleracea Powder (BOP) is a cheap material that can be obtained from regular kitchen waste. In this comprehensive study, BOP was analyzed and tested for the removal of cationic and anionic dyes on the basis of model contaminants - methylene blue (MB) and Congo red (CR). Through batch experiments, it was observed the prepared BOP exhibited remarkable rapid removal efficiency of 96% of MB and 63% of CR within just one minute. The adsorption kinetics were mathematically modeled, with the experimental data conforming to the pseudo-second-order mechanism for BOP for both dyes. Analysis based on Langmuir and Freundlich isotherm models revealed exceptionally high maximum capacities for BOP, 620 mg/g for CR, and 1511 mg/g for MB. With real wastewater samples, significant removal of both cationic and anionic dyes was achieved, thus, demonstrating the ability of renewable material for practical environmental applications. The highest adsorption capacity was achieved at 1516 mg/g for CR and 1270 mg/g for MB in the samples collected from the Baltic Sea. The obtained material was characterized typically by performing routine tests to which adsorbents are subjected in dried form such as Brunauer Emmett Teller (BET) isotherm, scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR).

Keywords: cabbage powder; dye adsorption; wastewater treatment; environmental toxicology

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Raw Materials and Waste

Parallel session

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In-depth characterisation of landfill fine fraction: assessing suitability for biocover construction and microplastics pollution

Landfills occupy extensive areas across Europe; however, landfill mining has uncovered their potential as valuable resource repositories. A significant portion of excavated material during landfill mining comprises a fine fraction (FF), which has been relatively underutilized for resource recovery. However, FF holds promise for biocover construction to address methane emissions. This study aimed to conduct a comprehensive and in-depth analysis of FF with a specific focus on identifying the optimal layer for biocover construction. Drilling operations were carried out at an ageing landfill in Lithuania up to 10.5 meters. FF samples were extracted at regular intervals of 1.5 meters. The characterisation included an extensive array of physical (moisture content, bulk density, water holding capacity, and particle size distribution) and chemical (organic content, pH, and conductivity) parameters, along with assessments of heavy metals and microplastics concentrations, considering their environmental significance. The study unveiled significant parameter variations across different depths, accompanied by medium-high correlations between specific parameters. Notably, a substantial correlation was observed between microplastics and mercury concentration. A comprehensive analysis, considering various depths and parameters, pinpointed the layer at a depth of 4.5–6 meters as the most suitable for biocover construction. However, this layer was characterized by the highest microplastics concentrations (30208±2728 particles kg^{-1}), posing a potential challenge. Moreover, microplastics become finer with increasing depth, heightening associated risks. Consequently, FF can be used for biocover construction, but a detailed depth analysis is needed to determine the best layer of FF based on both physical-chemical parameters and pollutants concentrations.

Keywords: microplastics; landfills; fine fraction; biocover

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Power-to-gas implementation into biogas upgrading plant

The environmental challenges generated due to CO_2 emissions are becoming a main priority in many countries to reduce global warming. The continuous implementation of CO_2 emission reduction targets opens new carbon capture and utilisation technologies opportunities. Carbon capture, storage, and utilisation (CCSU) are used to address these targets and find new solutions to reduce greenhouse gas (GHG) emissions.

Independently, renewable energy sources (RES) expansion, such as wind power or photovoltaics, reduces the use of fossil fuels and faces the energy balance between supply/demand. This improvement provokes an overproduction period. It is necessary to implement energy storage and CCSU technologies, which are becoming increasingly relevant for the future Energy System; one of these technologies is Power-to-Gas. H_2 production by proton exchange membrane electrolysis (PEM) may store the fluctuating electricity generated from RES, and biogas upgrading offers fossil natural gas substitution, producing renewable natural gas (RNG) or biomethane by capturing CO_2 from biogas. Biogenic CO_2 from Carbotech Gas Systems GbmH PSA biogas upgrading technology and green H_2 from RES are combined to produce Synthetic Natural Gas (SNG). This method increases the CH_4 production and yield compared to a traditional upgrading facility.

COMSOL Multiphysics is used for the PEM Electrolysis modelling, and Aspen Plus integrates the engineering modelling of the whole process. This study compares biogas upgrading technologies to be attached to Power-to-Gas systems and analyses the performance of different catalysis.

Keywords: biogas upgrading; carbon capture; storage and utilisation; energy storage; power-to-gas

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Multioxide nanomaterials containing manganese and copper as nanozyme catalysts in the decomposition of methylene blue dye

Advances in nanotechnology have paved the way for the synthesis of nanoparticles with controlled properties and one type of such materials with catalytic properties are nanozymes. Nanozymes can operate effectively outside the typical parameters of temperature and environmental conditions compared to enzymes without significantly impairing their catalytic activity. They are currently being investigated as catalysts and sensors and their use for environmental applications is still under development. However, nanomaterial systems containing mixed oxides as nanozymes are less widely explored.

The aim of this study was to obtain and compare the activity of ZnO-MnO-CuO and MnO-CuO multioxide nanomaterials with nanozymatic properties. The materials contained manganese and copper oxides, due to the presence of these elements in the active centres of the enzymes, and zinc oxide, as a photocatalytic material. The average phase sizes of the crystallites were around 30nm. The combination of oxides with enzymatic and photocatalytic properties allowed a series of tests comparing these materials in the decomposition of a model pollutant, methylene blue dye. As a result, nanomaterials reached 71,92% and 52,72% decomposition in UV light, respectfully. To investigate enzymatic activity, proteolytic tests were carried out with casein decomposition, peroxidase activity in H_2O_2 decomposition and activity towards the ABTS radical were determined. Proteolytic tests resulted in activity of the materials was 0,20 U/ml for MnO-CuO, 48% of pure enzyme activity. ABTS radical activity was 218 μmol/ml for ZnO-MnO-CuO and 377,56 μmol/ml for MnO-CuO in TROLOX equivalent. In summary, it was possible to obtain inorganic enzyme-like materials for dye decomposition.

Keywords: nanozymes; multimetallic nanooxides; water pollutants; dye decomposition

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Environmental impact of olive mill waste and hydrochar synthesis for sustainable applications

The olive oil industry generates significant amounts of waste, particularly in the form of olive mill waste (OMW), presenting a pressing environmental concern. This study investigates the environmental impact of OMW and proposes a sustainable solution through the synthesis of hydrochar via hydrothermal carbonisation. OMW, characterized by high acidity and phenolic content, poses challenges to soil and water ecosystems, leading to adverse effects on biodiversity and agricultural productivity. The disposal of OMW through conventional means, such as direct discharge or open-air evaporation, further exacerbates environmental degradation. To address this issue, our research focuses on the hydrothermal carbonisation of OMW to produce hydrochar, a carbon-rich material with potential applications in agriculture, water treatment, and renewable energy. The hydrochar synthesis process not only mitigates the environmental impact of OMW disposal but also transforms the waste into a valuable resource. By optimising hydrothermal carbonisation parameters, we aim to enhance the quality and versatility of the synthesized hydrochar.

The study explores the physicochemical properties of hydrochar and evaluates its efficacy as a soil amendment to improve soil fertility and structure. Additionally, we investigate the potential of hydrochar for water remediation, focusing on its adsorption capabilities for removing pollutants and enhancing water quality. Furthermore, the synthesized hydrochar will be assessed for its applicability in energy storage and as a renewable fuel source.

Keywords: environment; olive mill waste; hydrothermal carbonisation; hydrochar

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Conserving raw materials and energy through recycling of construction and demolition waste in resource challenged economies through principles of circular economy: a case study from Bangladesh

Efficient management of construction and demolition (C&D) waste is critical for sustainable resource utilisation and responsible waste practices. In Bangladesh, a surge in construction activities has led to a significant increase in C&D waste production. Surprisingly, comprehensive data on the rate of C&D waste generation and management in Bangladesh has been lacking until now. This study, conducted during the Fiscal Year 2022-23, aims to fill this knowledge gap by providing waste generation rates (WGR) for specific C&D materials and developing a circular economy model for the recovery and recycling of C&D waste, focusing on sites within the 12 city corporations of Bangladesh. The research reveals that demolition waste primarily consists of concrete (45%), brick (14%), ceramics (12%), and mortar (11%), while construction waste predominantly includes concrete (67%), brick (11%), mortar (5%), and timber (3%). The specific WGR and composition of C&D waste are quantified using regression analysis. Notably, for Dhaka, the capital of Bangladesh, the C&D WGR for the fiscal year 2022-23 stands at 64.68 kg/m^2 and 1626.97 kg/m^2, respectively. Unfortunately, a substantial portion of this waste is improperly disposed of in landfills. The study emphasises the potential for entrepreneurial ventures in recycling and reusing materials such as concrete, brick, metal, and ceramics, which can lead to reduced CO_2 emissions and energy usage. The findings offer crucial quantitative data for various stakeholders, including government entities, industries, and educational institutions. This data informs future strategies for C&D waste management in Bangladesh, aligning with the goal of achieving Sustainable Development Goal 12.

Keywords: Bangladesh; C&D waste; landfill; recycle; waste generation rate

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Phosphate adsorption by modified electric arc furnace ashes

The enrichment of phosphates in water leads to increased blooming of aquatic plants and decreased levels of dissolved oxygen in water, thus resulting in eutrophication. The most effective method of recovery of phosphorous from effluents with significant phosphate concentration is precipitation. On the other hand, wastewater with lower phosphate concentrations may be treated through adsorption. Researchers developed several materials for phosphate adsorption but our research was focused on the implementation of the idea of a circular economy and repurposing waste materials such as electric arc furnace (EAF) ashes. This study presents the successful development of an adsorbent which was obtained by a partial dissolution of EAF ashes in an HCl solution and surface recrystallisation of iron oxo-hydroxide by mixing with an alkaline solution. Batch adsorption experiments showed that the adsorption on synthesized materials reaches equilibrium within 150 minutes and is about five times greater than that of the pristine EAF ash. FTIR spectra of modified materials exhibited O-H stretching bands at 3300 cm^{-1} and H_2O bending bands at 1630 cm cm^{-1}, confirming iron oxo-hydroxide crystallisation. Moreover, FTIR spectra recorded after adsorption experiments included new bands around 1030 cm^{-1} corresponding to adsorbed PO_4^{3-} groups. Proven, high adsorption capacity of synthesized materials indicates the possibility of further application in wastewater treatment. Additionally, the ferrimagnetic properties of the materials enable convenient recovery from the solution by magnetic separation. Overall obtained materials could find an application both as a cheap way to decrease phosphates concentration and as a way to deal with industrial waste.
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Keywords: phosphate adsorption; EAF ashes; magnetic separation; ferrihydrite

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Preparation and optimisation of lignin-based metal catalysts for transformative oxidation reactions

In today's society, marked by rapid technological progress, there is a growing emphasis on adopting cost-effective and environmentally friendly bio-based materials across various industries. In line with this trend, our research focuses on the functionalisation of lignin, the foremost source of bio-polyphenols in the natural world, using a bimetallic catalytic system comprising iron and nickel. The primary objective of our work involves the characterisation of this lignin-based catalyst and its application as a promoter for expediting the oxidative degradation of certain pollutants, such as bromothymol blue (BB). This pollutant is known to have adverse effects on contaminated wastewater, making its efficient removal of paramount importance.

To gauge the effectiveness of our catalytic system, we conducted a series of comprehensive physicochemical tests. The results of these tests showcased the catalytic system's remarkable performance, achieving an impressive 98% conversion rate of BB under optimized conditions. This outcome signifies the catalytic system's high responsiveness in addressing the targeted application, highlighting its potential as an environmentally sustainable solution. Furthermore, the successful development and application of this bio-based catalyst open doors for broader utilisation of bio-polymers in various oxidative transformations and other forthcoming applications, ushering in a more sustainable approach to catalysis within the realm of bio-based materials.

Keywords: lignin; functionalisation; oxidation; bromothymol blue

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Raw Materials in Green Deal Strategies

Parallel session

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Life cycle & cost assessment of recycling aerospace composite materials

Composite materials have become increasingly popular due to their unique properties and versatility. Polymer matrix composites containing continuous aligned carbon fibers as reinforcement are the dominant advanced lightweight materials for high-performance structural applications such as aerospace. Today, end-of-life composite materials are being deposited directly in landfills. However, current recycling solutions seem to be very promising specifically in terms of their environmental impact. Life cycle assessment (LCA) is a vital tool that provides a comprehensive and holistic evaluation of the environmental impact of a process. Additionally, Life Cycle Cost (LCC) can provide crucial information about the economic performance of a process or service. In this work, we will present a novel LCA and LCC framework for the recycling of (CFRP) composite materials. Our specific scenario will study the environmental and economic performance/benefits/advantages of the mechanical and chemical recycling of CFRP composite waste from the aerospace sector and its recycling benefits; economic and environmental in the reuse of r-CFRPs. The OpenLCA software is used and the LCIs built for the scenarios consist of mainly primary data resulting from the project and partners' expertise. Results considering the chemical (solvolysis) and mechanical recycling processes; although the two may range in production from lab-scale operations to commercial ones, indicate to be in favour of mechanical recycling process in matters of GHG (greenhouse gasses) and acidification impact factors. Concluding, both mechanical and chemical recycling processes have a positive impact both on the environment and the costs when compared with landfilling.

Keywords: composites; aerospace; recycling; life cycle analysis; life cycle cost; waste management

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Fermented rye bran as biocide replacement in paper production

Microbial contamination causes environmental and costly problems in paper production. Today, chemical-based biocides are used to control these problems. We have developed a biocide substitute that consists of fermented rest products from the cereal industry. Rye bran is a suitable nutrient for growth of a selected strain of Lactiplantibacillus plantarum. Previous studies have shown that fermented rye bran contains bioactive metabolites that powerfully limit virtually all bacterial growth. The cereals also contain fibres with potential to be a supplement in the raw material (pulp) of paper production. Our intention with this study was to investigate the potential of fermented rye bran as an antibacterial raw material in paper production. We will specifically determine the antibacterial effect of fermented rye bran on bacterial strains isolated from pulp and process water at a paper mill. In addition, to analyse the effect of the single metabolites discovered in the fermented rye bran. The results showed that fermented rye bran inhibited growth of the majority of the bacterial strains isolated from the paper mill. The pure metabolites showed also antibacterial properties, but less potent in comparison to the crude fermented rye bran product. The Lactobacillus strain used in the present study was resistant to all the tested metabolites. In conclusion, fermented rye bran shows properties indicating potential to be used as a bioactive raw material, limiting the need to add antimicrobial chemicals in paper production.

Keywords: paper production; Lactoplantibacillus plantarum; fermentation; rye bran; antimicrobials

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New active packaging based on electro-blow spun hybrid nanofibers

Integrating biodegradable polymers in producing nanofibers for active food packaging is a promising approach for environmentally friendly solutions. These polymers, sourced from renewable materials, break down naturally over time, reducing the ecological impact. Incorporating them into nanofiber structures improves the resulting packaging material's strength and flexibility. The high surface area of nanofibers also allows for the incorporation of active agents, such as antimicrobials, enhancing the packaging's functionality. This eco-friendly packaging extends the shelf life of food products and reduces plastic pollution, aligning with the global trend towards sustainable practices in the food packaging industry.

Gelatin/Chitosan/polyamide 6 hybrid nanofiber was prepared through the electro-blow spinning technique, a hybrid nanofiber manufacturing technique that combines the benefits of both solution blow spinning and electrospinning. In this technology, the electric field aids in the uniform stretching of the solution, resulting in more uniform fibers of higher quality. Incorporating Cedrus atlantica essential oil improves the antimicrobial activity of the resulting nanofiber, making it suitable for food packaging applications. In addition, the morphological properties, thermal behavior, FTIR analysis, contact angle, air permeability and mechanical properties of the hybrid nanofibers were determined. This study has yielded promising results for the hybrid nanofibers produced. These nanofibers exhibit favorable thermal properties and thin morphology with an average diameter of around 410 nm. Notably, the contact angle measurements showed values exceeding 90°, indicating hydrophobic characteristics, a valuable attribute for food packaging applications. The originality of this study lies in producing a hybrid nanofiber, implementing an electro-blow spinning technique with a higher mechanical and antibacterial efficiency for food packaging applications.

Keywords: electro-blow spinning; food packaging; hybrid; nanofibers

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Development of bioenergy and biofertilizer from sea weeds

Anaerobic digestion (AD) of organic wastes is among the most promising approaches used for the simultaneous treatment of various waste streams, environment conservation and renewable bioenergy generation (biomethane). Nevertheless, efforts should be devoted to decreasing the price reduction of natural fuels, so that the enhanced biogas and methane production by over 90%, compared to control, would be more economically justified, facilitating the large-scale application of these compounds. The present study development of bioenergy and biofertilizer from sea weeds, adopted a new but existing technology for the sustainable production and development of biogas as well as biofertilizer by using sea weeds. An enrichment process of developing organic fertilizer by improving the level of NPKs through a sustainable development of plant growth as well as yield of production. Hence, the sustainable application could be developing a biofertilizer and is slowly setting its pace and creating an evolution of the downfall the demand of the use of chemical fertilizers in the near future.

Keywords: anaerobic digestion; organic waste; sea weeds; biogas; biofertilizer; NPK

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Synthesis of hydrogel materials in accordance with the principles of green chemistry

Hydrogel materials are of great interest in the fields of pharmacology and medicine due to their remarkable properties as carriers of active substances. These materials form polymer networks, enabling them to absorb significant amounts of water and other substances. This unique feature ensures a controlled and sustained release of active ingredients, which is of great importance in medicine.

This study focuses on the synthesis of hydrogel materials integrated with green chemistry principles and photopolymerisation technology. Green chemistry, as a philosophy guided by sustainable and safe chemical practices, is the foundation for this project. Research includes the use of green raw materials and the elimination of toxic solvents, with an emphasis on minimising environmental impact. The photopolymerisation method, based on the initiation of the polymerisation reaction using light, has been used to achieve controlled and efficient synthesis of hydrogel materials.

In analysing photopolymerisation from a green chemistry perspective, particular attention was paid to the precise control of the reaction and polymerisation rate, resulting in optimised synthetic conditions. Results confirmed that the implementation of green chemistry principles in combination with photopolymerisation leads to hydrogels with controlled properties and minimal environmental impact. In the context of potential applications, particular emphasis was placed on the therapeutic potential, especially in the areas of drug carriers in anti-cancer therapy or biomaterials in tissue engineering.

This innovative combination of technologies opens up new horizons in the field of biomaterials, highlighting the potential for sustainable practices in science and technology.

Keywords: hydrogel; pharmacology; photopolymerisation

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Synthesis, crystal structure and application as adsorbent materials of organic dye of a new magnesium phosphite $[Mg(H_2O)_6][Na_2(H_2O)4](HPO_3)_2$

The novel magnesium phosphite $[Mg(H_2O)_6][Na_2(H_2O)_4](HPO_3)_2$ was created by reacting magnesium oxide with H_3PO_3, and the structure of the compound was identified using a single-crystal X-ray diffraction approach. The hybrid phosphite $[Mg(H_2O)_6][Na_2(H_2O)_4](HPO_3)_2$ crystallized in the Orthorhombic structure *Pnnm* space group, Z = 2, with the cell parameters a = 12.3191 (5) Å, b = 8.9563 (4) Å, c = 7.2018 (2) Å, and V = 794.60 (5) Å^3, R(F) = 0.018, $wR(F^2)$ = 0.085. There are $[Mg(H_2O)_6]^{2+}$, $[Na_2(H_2O)_4]^{2+}$ cations and $(HPO_3)_2^{4-}$ anions in its crystal structure. The compound was characterized by thermogravimetric studies (TGA) and infrared spectroscopy (IR). The phosphite anion and water molecules were confirmed by IR spectroscopy, and the TGA test revealed that the compound was stable up to 90°C. The effectiveness of the synthetic magnesium phosphite complex was used as an adsorbent for methylene blue dye (MB) in aqueous solutions. The maximum percentage of methylene blue dye (MB) clearance was shown to be 89.02%. A UV-visible spectrophotometer was used to analyse the sorption process. MB adsorption on $[Mg(H_2O)_6][Na_2(H_2O)_4](HPO_3)_2$ was adjusted by the Freundlich isotherm with correlation coefficient R^2 = 0.9637. the Gibbs free energy change is negative, indicating that the sorption of MB onto $[Mg(H_2O)_6][Na_2(H_2O)_4](HPO_3)_2$ is spontaneous. In addition, the enthalpy changes are positive, indicating that the sorption is endothermic. The pseudo-second-order kinetic sorption process with a higher correlation coefficient (R^2 > 0.99) considers that the sorption mechanism is affected by the chemical sorption of the surface adsorption mechanism.

Keywords: phosphites; X-ray diffraction; infrared spectroscopy; TGA-DTA analysis; methylene blue dye removal

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Remarkable photocatalytic activity of TiO_2 doped ferroelectric $LiTa_{0.5}Nb_{0.5}O_3$ for organic dyes degradation

In this study the Titania doped $LiTa_{0.5}Nb_{0.5}O_3$ ferroelectric powder was synthesized via a conventional solid-state reaction method. The crystal structure of the samples were characterized on an X-ray diffractometer. The size and surface morphology of the particles were investigated via scanning electron microscopy (SEM/EDS) and (TEM). The photocatalytic activity of the catalysts were investigated using a Rhodamine B (RhB) aqueous solution as a model organic substrate. The results showed that the $LiTa_{0.5}Nb_{0.5}O_3$-TiO_2 powder has excellent photocatalytic degradation performance. The effects of catalyst loading and the initial concentration of the RhB solution on the photocatalytic activity were also investigated in this study.

The studied samples show a catalytic degradation ratio of rhodamine B (RhB) dye reaching 98% under UV irradiation. The results indicate that the $LiTa_{0.5}Nb_{0.5}O_3$-TiO_2 particles can be applied as attractive ferroelectric catalysts for organic pollutant degradation.

Keywords: ferroelectric materials; TiO2; dye degradation; photocatalysis; reusability

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Sustainable Development Goals part I

Parallel session

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Development goals towards sustainability

The lofty Sustainable Development Goals (SDGs) seek to safeguard the environment, end poverty, and ensure that all people live in peace and prosperity. This new section of Sustainability https://www.mdpi.com/journal/sustainability/sections/Development-Goals-towards-Sustainability strongly advocates for an interdisciplinary approach that embodies sustainability in its purest form-beyond a self-serving perspective by taking into account the needs of all members of society, including future generations. Development goals will enable the adoption of sustainable behaviors and practices in this way. In order to support spreading awareness about The 2030 Agenda for Sustainable Development and the integration of the SDGs into our daily lives, it is highly recommended that the authors highlight the SDGs they intend to achieve.

Keywords: sustainable development; sustainable development goals; sustainability

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Circular threads revolutionising fashion sustainability

The fashion industry, currently the second-largest contributor to environmental pollution, urgently needs innovative strategies to mitigate its negative impacts. Businesses and citizens are also changing their habits, but the sustainability challenges that the changes implemented are not yet sufficient. The idea of this work is to evaluate the impact leasing has in terms of a circular solution and how much it can be proposed as an alternative to the traditional fast fashion model. A multi-criteria decision analysis (MCDA) is used in which different leasing characteristics are compared: raw materials, transport, human conditions, waste management and production management. MCDA that was realised with the contribution of different categories of stakeholders.

Within the take, make and waste model, much importance is given to the waste phase and in particular the two most relevant criteria are: i) access-based model and ii) best care. Results reward the leasing model ensuring ethical conditions for workers, followed by the relevance of raw materials, emphasising recycling or organic sources. The analysis of the results highlights the relevant role assigned to the social sphere, which testifies to the need to strengthen efforts towards this dimension, which is instrumental in supporting circular practices in the fashion industry. The European Green Deal concerns the contribution of all sectors and the clothing sector is a pioneer in some countries. In order to be competitive and sustainable, some changes are also proposed in strategic choices and leasing shows potential to facilitate this green transition.

Keywords: circular fashion; innovation; leasing; multi-criteria decision analysis; sustainability

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A green gas for the sustainable transition: the role of subsidies in enhancing profitability from biomethane production

To solve the problem of environmental pollution in the transportation sector, new sustainable initiatives are needed. Biomethane is also known as green gas because of the ability to regenerate certain wastes, which makes it a leading factor in the resource circularity. The development of renewable resources is highly dependent on incentive systems in order to make them competitive with fossil fuels, and in this respect, this work measures the profitability of a biomethane plant according to the new incentive decree applied in Italy. The study evaluates small and medium-sized plants and considers two distinct types of substrates: i) organic fraction of municipal solid waste (OFMSW) and ii) by-products. The economic analysis consists of evaluating base and alternative scenarios, in which it will be measured how the Net Present Value (NPV) varies as a function of the main critical variables.

The results show that there are significant differences compared to the previous decree, as although OFMSW management can count on additional revenues from the management of these wastes, the favourable incentives significantly reward by-products. This work does not indicate that only one substrate needs to be valorised, but rather emphasises that it is necessary to valorise both and therefore changes to the incentive scheme are suggested. Gas, the least impactful fossil source, will support the transition process. In the context of analysis where green gas is used, it will make it easier to achieve the decarbonisation goals of the European Green Deal and the goal of energy independence.

Keywords: biomethane; circular economy; economic analysis; subsidies; sustainability

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Scaling the peaks of circularity

The theme of the circular economy (CE) aims to support sustainable development and Europe shows policies and practices that move towards this goal. A necessary tool to measure the progress of circularity can be an overall indicator that incorporates the contribution of the individual indicators. In this regard, we use a multi-criteria decision analysis (MCDA) based on Eurostat data for 2019-2020 in Europe. Evaluations provided by academic experts, using the Analytic Hierarchy Process, identify that the categories with the greatest impact on the overall indicator are 'competitiveness and innovation' and 'global sustainability and resilience'. Specifically, it is the private investment and gross added value related to circular economy sectors indicator that is most indicative of the good performance in terms of circularity of European countries. The results show that the western countries show a very interesting performance, while the eastern countries have less impactful circularity measurements. Belgium prevails in the baseline scenario ahead of Italy and France. In addition, an alternative scenario was proposed in which the indicators identified in Eurostat are assigned equal importance and the results confirm Belgium in first place, this time ahead of the Netherlands and Italy. European Green Deal is an ambitious project that also requires the fundamental contribution of the circularity of raw materials, as they are essential to support the ecological transition by increasing the foreign dependency of European countries and reducing geopolitical risks.

Keywords: circular economy; Europe; indicators; multi-criteria decision analysis; resource management

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A new perspective towards sustainable mobility: the role of e-fuel

The term e-fuel or electro-fuel refers to synthetic fuels that are chemically produced by the Fischer-Tropsch process using different inputs: green energy, CO2 captured from the atmosphere by the Direct Air Capture (DAC) process, and H2 obtained by electrolysis from water. The importance of these fuels lies in their 'zero net CO2 emission' characteristic in their production-use cycle: the amount of CO2 used for production is subsequently emitted during carburation. The objective of this study was to identify, by means of a techno-economic model, the levelled cost of e-fuel (LCOe-fuel) by previously passing through the levelled costs of energy (LCOE), CO2 (LCODAC) and H2 (LCOH). This resulted in LCOe-fuel being around 3.1 €/l. To this must be added the profits of companies in the value chain and state taxes with estimates that bring the market price above 4 €/l. Further analyses were implemented that considered alternative scenarios that were found to be in the range of 2.9-3.3 €/l in 65% of the analysed cases. The study emphasises the importance of the political role in enabling the development of pragmatic sustainability geared towards environmental, social and economic needs, a lowering of costs and the encouragement of subsidies for producers. Furthermore, e-fuel actively responds to SDG7 by representing an alternative to fossil fuels, encouraging the total abandonment of the latter. The European Green Deal moves the decarbonisation of the transport sector and e-fuel supports this transition.

Keywords: cost analysis; hydrogen; e-fuel; renewable energy; sustainable development

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Analysing the drivers and barriers to bio-based fertiliser (BBFs) adoption in farming practices – Polish case of study

The global agricultural sector is under increasing pressure to adopt sustainable practices, with a particular focus on enhancing resource recovery. A notable shift involves the replacement of conventional fertilisers with bio-based alternatives derived from waste sources. Paper presents a comprehensive analysis of drivers and barriers influencing the adoption of bio-based fertilisers (BBFs) in farming practices in Poland. The scope of work included conducting a survey of Polish farmers using Paper and Pen Personal Interview (PAPI) method. The survey deadline was December 2021. Farmers representing all 16 voivodeships in the country were analysed.

The results showed that the key drivers for the usage of BBFs include their positive effect of BBFs on soil properties and health especially regulation of the pH, accumulation of water and nutrients in the soil, and positive effect on the soil microorganism's growth. The recognition of BBFs as a means to foster sustainable fertilisation practices, the growing consumer demand for environmentally friendly and organic products, and legal restrictions on chemical fertilisers are also substantial factors. However, significant barriers limit widespread adoption. High application costs, including expenses related to transport of fertilisers, poses a major economic challenge. Moreover, there are concerns about consumer acceptance of waste-derived fertilisers, especially those sourced from human excrement. Lack of farmer experience and knowledge, limited fertiliser availability, environmental pollution concerns, and questions about impacts on consumer and crop health further hinder adoption.

To address these barriers, collaborative efforts are essential the presented findings provide valuable insights for stakeholders, enabling customer prospecting, policy development, and educational initiatives to promote sustainable agricultural systems. Ultimately, by embracing identified drivers and addressing barriers, stakeholders can contribute to a resilient agricultural system that minimises environmental impact and enhances resource efficiency.

Keywords: sustainable agriculture; bio-based fertilisers; BBFs; stakeholder analysis

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Sustainable Development Goals part II

Parallel session

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Exploring consumer habits in sustainable energy communities

Energy communities represent a new model towards the ecological transition and are spreading, driven by government incentive policies. This work looks into how users' habits help or hinder these renewable energy communities (RECs). For this purpose, a mix of different analytical methods is used. First, criteria within the four quadrants of the SWOT (strengths, weaknesses, opportunities and threats) of a REC are identified. This analysis allows us to identify the elements that will affect the social dynamics of a REC. In this direction, an on-line survey is then conducted in order to understand the habits and choices of Italian consumers. The results show that weaknesses are the category that has the highest relevance, and among the individual criteria, the one that has the highest relevance is financial savings on energy bills. Thus, it is evident how consumer perceptions move in different directions. This analysis allows us to focus on those aspects to be solved that complicate the realisation of a REC, but also to enhance those factors that can be enablers. The interactions between these factors are evaluated as the system requires their integration and allows for the combination of perspectives as this is precisely the direction of an energy community. The European Green Deal is based on citizen involvement, and RECs are an aggregation of resources useful for achieving sustainability goals.

Keywords: energy community; prosumer; renewable self-consumer; survey; sustainable development

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Hyperspectral based sensing architectures for resource circularity

We aim to contribute to the realisation of a circular factory in space through architectural techniques applied in the initial examination of recyclable materials and/or final products of recycling/recovery processes. Hyperspectral imaging (HSI) monitors the quality of the recycled material. Tests are conducted at the Sapienza University of Rome laboratories using materials supplied by Thales Alenia Space Italia within Spoke 5 - Closed-loop, sustainable, inclusive factories and processes of the Extended Partnership "MADE IN ITALY CIRCOLARE E SOSTENIBILE" (MICS). A key achievement of this first phase of the project was to identify proper data acquisition and management. The results show that the flow chart for the procedure applied for the analysis of the HSI data consists of the following steps: i) raw hyperspectral data; ii) pre-processing; iii) corrected hyperspectral-data; iv) exploratory analysis; v) classification and vi) prediction maps. Classified images demonstrated how the NIR range can be used to obtain precise predictions. Further research is necessary to identify a smaller set of wavelengths that can yield the best classification model. In addition, fresh kinds of samples will be examined in order to evaluate the HSI process on a bigger sample size. Another implication of this work is the relevance of business-university collaboration that can exchange resources-competencies in order to realise a sustainable and circular model.

Keywords: circular economy; hyperspectral imaging; space; sustainable development

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Profitability analysis of a grid-connected photovoltaic system: a project to promote sustainable development in Palestine

Energy for sustainable development is a central issue in combating climate change. Moreover, SDG 7 (Affordable and Clean Energy) requires the contribution of all countries. The Palestinian territory has a consistent energy potential that is yet to be exploited. This work aims to assess the profitability of a residential photovoltaic (PV) system. The analysis is based on the discounted cash flow method and considers different market and policy scenarios in which the impact of the avoided cost in the bill and the role of Net Metering are studied. Several critical variables are varied to give robustness to the results obtained, and the results show how profitable the investments can be. The NPV fluctuates between 935 $ and 14,055 $ in the Low Market setting and between 6,130 $ and 28,210 $ in the High Market one. In nearly all Net Metering situations, profitability seems to be confirmed. When Net Metering is not available, instead, the NPV becomes positive after 31% and 48% self-consumption for the High Market and Low Market settings, respectively. The European Green Deal is not just about European countries, but about fostering the green transition of all countries and there is a need for collaboration between countries globally because sustainability is achieved when we are united.

Keywords: sustainable development; profitability; photovoltaic; net metering

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Ai meets environmental policy: a novel approach to carbon leakage in the EU emission trading system

The transition to a green and digital economy is reshaping industrial operations and strategies worldwide. This study addresses the challenges and opportunities within the European Emissions Trading Scheme (EU ETS) in the context of achieving climate neutrality by 2050. We focus on the risk of carbon leakage and explore methodologies to counteract this while enhancing global competitiveness.

Our research utilises a Long Short-Term Memory (LSTM) neural network model to predict the price of European Union Allowance (EUA) based on various financial energy futures. The model demonstrates robustness, predicting the EUA price to oscillate between 78 and 91 €/tCO_2. Additionally, a Multi-Criteria Decision Analysis (MCDA) is applied to evaluate policy alternatives for businesses under the EU ETS. The study incorporates insights from academic and industrial experts, highlighting two critical criteria: public expenditure with expected benefits and the industrial ecosystem.

The policy implications of our findings suggest that incentives for innovative solutions protecting energy and raw material components are essential. This aligns with the framework of the 3Es - Energy Efficiency, Renewable Energy, and Circular Economy, underscored by digital development. Our research contributes a novel methodological approach combining neural networks and multicriteria analysis, offering valuable insights for policymakers and businesses in the context of sustainable and competitive global operations. The European Green Deal needs a high carbon price to discourage unsustainable choices.

Keywords: artificial intelligence; carbon leakage; emissions trading scheme; multicriteria decision analysis; sustainability

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Energy communities with new incentive policies

Renewable energy communities (RECs) emerge as a new social model to achieve sustainability goals. The challenge requires a transformation of cities, which are called upon to be fast and sustainable. To realize smart cities, a decentralized and collaborative energy model is essential, and renewable energy communities serve as a key component. This study endeavours to present an economic evaluation of residential photovoltaic (PV) plants considering the potential incentives that could be assigned to RECs in Italy. Furthermore, to give solidity to the results achieved, several alternative scenarios are assessed according to critical variables.

The results show the profitability of these plants and the value of the subsidy, the price of self-consumed energy and the percentage of self-consumption influence the Net Present Value (NPV). In particular, it emerges that the NPV is 9-93 k€ higher in the High-Subsidy context than in the Low-Subsidy context, depending on the percentage of self-consumption. Thus, the implications of this work suggest that behaviours that synchronise consumption and production phases should be rewarded. The subsequent analysis aims to assess how to divide the benefits obtained within RECs and three distinct approaches are proposed: i) revenues split equally; ii) revenues shared entirely according to energy consumption profile and iii) revenues shared according to a partial energy consumption profile. The latter approach seems to be the one that can harmonise choices among renewable self-consumers and the European Green Deal can be achieved through the development of RECs within even large urban contexts by optimising the space available.

Keywords: economic analysis; energy communities; subsidies; smart cities; sustainable cities

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Novafert - SWOT analysis of usage waste-based fertilisers in Poland

Increasing world population exerts pressure on many economic sectors. Among them is the agricultural sector, where emphasis is placed on sustainable farming and practices of a circular economy (CE) including the use of fertilisers derived from secondary sources. This aims to address both environmental issues and the increasing demand for agricultural productivity. Numerous initiatives supporting an economy based on the CE model are being undertaken. One such initiative is the Novafert - Novel Procedures and Sustainable Guidelines to Enhance the Use of Alternative Fertilisers project.

As part of the Novafert project, a comprehensive SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was conducted to assess the prospects and challenges related to the adoption of waste-based fertilisers, such as sewage sludge, animal manure, and digestate, in the agricultural sector of Poland. The mentioned analysis is presented in this paper and includes key aspects raised by participants of the Regional Working Group and interested stakeholders. The strengths of waste-based fertilisers in the Polish context are examined, considering factors such as their potential to reduce dependence on traditional chemical fertilisers, mitigate environmental pollution, and contribute to the CE by recycling organic waste. Concurrently, the study explores the weaknesses, encompassing issues such as potential contaminants, and logistical challenges in sourcing and processing waste materials. Opportunities stemming from the adoption of waste-based fertilisers are highlighted, including the potential for cost savings, improved soil health, and alignment with sustainable agriculture practices. Conversely, threats to widespread adoption were scrutinized, including regulatory constraints and the need for significant investments in infrastructure.

The outcomes of this paper aim to inform strategic decision-making processes, encouraging the development of policies that foster sustainable agricultural practices. The findings contribute to the ongoing discourse on sustainable agriculture, offering policymakers, farmers and other stakeholders a balanced perspective on the potential benefits and challenges associated with incorporating waste-derived fertilisers into mainstream agricultural systems.

Keywords: SWOT analyses; waste-based fertilisers; sewage sludge; animal manure; digestate

Acknowledgments: Paper was prepared as part of the project "Novel Procedures and Sustainable Guidelines to Enhance the Use of Alternative Fertilisers (Novafert)" which received funding from European Union, project no.: 101060835.

Novafert

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Innovative Materials for Sustainable Future

Parallel session

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Factors of recycling of end-of-life photovoltaic modules

Photovoltaic (PV) solar modules play a key role in the transition to clean energy systems. When we talk about clean energy, not only a renewable energy source is of importance, but also a sustainable management of materials of generators throughout their life cycle is required. Thus, with the increase in PV power installation, it is needed to analyze the end-of-life stage of PV.

The goal of the study was to review the literature on the main factors affecting PV waste treatment and preparation for recycling. Three aspects have been highlighted: technological, legislative, and economic. Recycling technologies are of two types: downcycling and upcycling. The existing laminated glass or electronic waste recycling facilities are usually involved in downcycling. They recover materials, which constitute the biggest share in mass of the modules (glass, aluminium). However, the quality of recovered materials is usually low, as well as the variety of recovered materials is low compared to the materials composition in PV modules. Upcycling requires more processes and is more complicated, but it allows additional recovery of important elements, which are present in PV modules in smaller amounts (silver, silicon).

European Union Waste Electrical and Electronic Equipment (EEE) Directive explicitly mentions photovoltaic panels as one of the categories of EEE. On the basis of "extended producer responsibility" principle a minimum collection rate and recovery/recycling targets set in the directive must be achieved.

The costs of recycling PV waste usually overcome the possible revenues of recovered materials. A low amount of waste increases collection, transportation, operational, and capital costs making recycling economically ineffective.

All the above-mentioned aspects are interconnected, and further improvements are necessary for each of them to fulfill clean energy goals.

Keywords: clean energy; photovoltaic waste; recycling; circular economy

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Comparison of changes in the morphology of two straw varieties: the impact of treatment methods

In recent years, there has been a worldwide concern about sustainable development and the use of eco-friendly materials. The application of wheat straw in the construction industry has therefore attracted a considerable interest, as wheat straw can be used as a reinforcing additive in the production of eco-buildings or low-carbon building materials. Wheat straw contains cellulose, hemicellulose, and lignin as well as organic substrates and extractives, which makes the surface of straw less compatible with the binding material. Many chemical and physical pre-treatment strategies have been proposed to increase matrix-biomass adhesion and, hence, the ultimate performance of cement-free composites. However, the impact of environmentally friendly treatment methods on different wheat species remains undiscussed. Therefore, the aim of this study is to investigate changes in the morphology of two wheat varieties (S1 and S2) after thermal and non-thermal treatment. SEM-EDS, FTIR and TGA results revealed that the wheat variety and the treatment method both has a significant impact on the morphology of wheat. It was observed that after thermal treatment, the phloem cells of the S2 wheat were more damaged than those of the S1 sample however, the level of wax removal was lower. The non-thermal treatment was less effective in removing hemicellulose or other constituents, although it induced the reduction of silicon content on the outer surface of wheat, indicating the destruction of siliceous layers. Results suggest that the S1 straw after thermal pre-treatment should be more compatible with the binding material.

Keywords: wheat straw; treatment; surface; wax; silicon

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Eco-friendly and efficient chitosan/tea waste composite beads for removal of dyes and polycyclic aromatic hydrocarbons from aqueous matrices

Renewable tea waste was coalesced with chitosan to develop biodegradable composite (CS/TW) beads as adsorbent used for wastewater treatment. CS/TW beads were characterized using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and Brunauer-Emmett-Teller (BET) analysis to determine their composition, morphology, and specific surface area under dehydrated conditions. The adsorption capacities of CS/TW beads were assessed for methylene blue (MB), Congo red (CR), naphthalene (Naph), and phenanthrene (Phen). Batch experiments were conducted to investigate the effects of adsorbent dose, contact time, thermodynamics, pH, salts, and acid on the adsorption process. Pseudo-first-order and the pseudo-second-order model were used to correct the time evolution. Dyes exhibited a better fit to both models, while the PAHs showed a stronger fit to the pseudo-second-order model. Outcomes revealed that the adsorption process obeyed the Langmuir, Freundlich, and Jovanovic Multilayer model for MB, CR, and PAHs, respectively. Maximum adsorption capacities for MB, CR, Naph, and Phen were 262.82, 86.51, 33.71, and 12.74 mg/g accompanied by impressive removal efficiencies of 99.66%, 68.92%, 88.92%, and 75.14%, respectively. Furthermore, effective removal of dyes and polycyclic aromatic hydrocarbons was observed in the treatment of real wastewater samples. The maximum removal efficiencies obtained were 92.05% for MB in river water, 98.98% for CR in the Baltic Sea, 89.11% for Phen in river water, and 93.35% for Naph in tap water.

Keywords: tea waste; chitosan; chitosan composite beads; organic pollutants; adsorption

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Extraction and valorisation of cellulose nanomaterials: from sustainable sources to innovative applications

The increasing global concern for sustainable materials and nanomaterials, coupled with the depletion of fossil resources, has driven a relentless quest for high-value, renewable alternatives. This presentation explores the remarkable potential of nanocelluloses (NC), including cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF), as a novel class of sustainable materials. These nanomaterials possess inherent renewable properties, biodegradability, biocompatibility, cost-effectiveness, and versatile physical and surface properties, making them highly sought after for diverse applications.

Our investigation delves into discovering innovative lignocellulosic sources for NC (CNC and CNF) production and their application as reinforcements in polymer matrices, yielding high-performance polymer nanocomposites. Through a combination of chemical and mechanical processes, we successfully transform raw cellulose sources into highly valuable materials with exceptional properties. Detailed physico-chemical characterisations of the cellulose sources and derived materials are presented. Furthermore, we showcase the incorporation of purified cellulose microfibers (CMF), CNC, and CNF into various biopolymer matrices, demonstrating their capability to enhance biopolymer properties while creating novel biopolymer-based nanocomposites with outstanding performance.

This presentation encapsulates the journey from sustainable cellulose sources to innovative applications, highlighting the profound impact of these cellulose nanomaterials on the development of environmentally conscious and high-performance materials for a variety of industries.

Keywords: nanocellulose; cellulose nanocrystals; cellulose nanofibrils; packaging

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Electrochemical methanol synthesis by CO2 reduction towards a new electrolyser design (eNetMIX)

Tackling climate change by mitigation of CO_2 emissions, is one of the undoubtedly most important challenges at the present time. At Net4CO_2 CoLAB our mission is to develop innovative decarbonisation solutions, from science to market, and accelerate the deployment of competitive and disruptive solutions for CCUS towards a more sustainable world. One of the approaches that has attracted considerable attention recently is the electrochemical reduction of CO_2 into value-added chemicals, with a large global demand, like methanol.

Methanol production from syngas, without carbon capture and sequestration, is unsustainable and harmful to the environment. In alternative, when using renewable energy sources as the power source, the CO_2 electrolyser can be used to produced green methanol from the direct electrochemical CO_2 reduction reaction (eCO_2RR) at the cathode, coupled to the oxygen evolution reaction (OER) at the anode, when fed with water. However, the main challenge has been the design of a high-performance CO_2 electrolyser, capable of competing with methanol production from syngas on the industrial scale.

The eNetMIX technology has already proven to be capable of boosting overall electrochemical reaction efficiency by enhancing mass- and heat-transfer, thus lowering energy needs. Hence, the aim of this communication is to showcase the proof-of-concept for an innovative design of a NetMIX-based CO_2 electrolyser device, to perform electrolytic reduction of CO_2 into methanol.

Keywords: CO_2 utilisation; carbon circular economy; decarbonisation; electrochemical methanol; eNetMIX

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Basalt boron fiber corrosion in alkaline medium

Innovations in construction materials are essential for creating resilient and sustainable structures. A significant alkalinity of Portland cement leads to corrosion of glass-type fiber-reinforced materials. The rate of fiber corrosion depends on numerous parameters such as temperature, ageing time, and chemical constitution of the fiber, but also the chemical composition of the ageing solution. There are known that basalt fibers have similar or better mechanical property – improved thermal and chemical stability – than that E-glass fibers. Basalt-boron fiber was derived from volcanic rock, and basalt fiber offers excellent strength and resistance to corrosion, making it an ideal reinforcement material for concrete. Introducing boron compounds further enhances the fiber's properties, resulting in improved adhesion to concrete and increased resistance to extreme conditions. The inclusion of basalt-boron fiber in concrete products offers multiple advantages, the first of which is enhanced strength. This innovative blend significantly reinforces concrete, extending its service life and reducing maintenance costs. The next advantage is improved durability. The fiber's resistance to environmental factors, including corrosion and extreme temperatures, makes concrete products more durable. The latest one is reduced ecological impact. Basalt-boron fiber is eco-friendly, offering a sustainable solution for construction. This technology solution finds applications in many concrete products, from infrastructure elements to architectural designs, providing a lasting solution in a dynamic industry. Using basalt-boron fiber in concrete products showcases the potential for a sustainable and resilient construction future. As the construction industry evolves, innovations like this pave the way for enhanced performance, durability, and environmental responsibility.

Keywords: basalt-boron fiber; corrosion; advantages; sustainable; additives

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Analysis of selected methods of post-mining soil reclamation and organic carbon sequestration

Supported reclamation of post-open-cast mining soils, coupled with the application of organic soil amendments, plays a crucial role in enhancing carbon sequestration in the soil. The implementation of organic amendments in soil reclamation after open-cast mining contributes to the improvement of soil structure and fertility, fostering the establishment of a sustainable ecosystem. Utilising organic soil additives in the rehabilitation process of open-cast mining areas not only aids in stabilising the soil but also facilitates the sequestration of carbon, promoting environmental sustainability. The incorporation of organic and organic amendments during the reclamation of post-mining lands promotes beneficial microbial activity, fostering nutrient cycling and organic matter decomposition, which collectively contribute to increased carbon sequestration in the reclaimed soil.

The main scientific objective was to analyze the potential, mechanisms, and dynamics of carbon sequestration in post-exploitation and reclaimed soils using various techniques. Specific objectives included characterising the impact of the applied reclamation technique on the process of organic carbon sequestration in the soil, determining the dynamics of carbon sequestration in areas at different stages of reclamation, and identifying the mechanism of carbon sequestration in soil layers in areas with varying degrees of reclamation advancement. The study established a correlation between the reclamation method and the potential for carbon sequestration. Specifically, the reclamation of post-mining areas using sewage sludge was found to enhance carbon sequestration in the soil. Temporal variations were observed in the dynamics of net CO2 flux and carbon sequestration at different stages of reclamation. This highlights the influence of time on carbon-related processes during the reclamation process. The research indicated that post-mining soils can effectively contribute to reducing atmospheric CO2 concentrations. This suggests a potential role for these soils in mitigating carbon emissions.

Keywords: SOC sequestration; remediation; soil carbon; CO2 soil emissions

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Requirements for data collecting and reporting by water and sewage companies in the context of the Green Deal and other new EU Regulations

New European Union regulations related to environmental protection and climate impose requirements on member countries for collecting, reporting, and publishing data for the public. The aim of this presentation is to provide an overview of chosen new EU legal regulations in the context of increased reporting requirements for water and sewage utilites. The presentation will provide information on the data that companies will have to report. The necessity of transparency will be underlined. The presentation will focus on the New Green Deal and other new regulations from the European Commission, such as the: Energy Efficiency Directive, Renewable Energy Directive, REPower EU, Circular Economy Action Plan, Sewage Sludge Directive, Industrial Emissions Directive, Urban Wastewater Treatment Directive, and Drinking Water Directive. Differences and similarities in the scope of data reporting from EU directives and national and international statistical and benchmarking reporting will be discussed.

Keywords: energy efficiency directive; REPower EU; sewage sludge directive; urban wastewater treatment directive; drinking water directive

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Water-Waste-Energy in Green Deal

Parallel session

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Influence of atmospheric plasma on the elimination of selected pharmaceuticals from water

Atmospheric plasma is an alternative to many processes based on the use of expensive chemical reagents. As reported in the literature, it is an environmentally friendly, operator-safe and low-cost process. The study was conducted to determine the effect of cold plasma (atmospheric plasma) on the elimination of selected pharmaceuticals from aqueous solutions containing selected pharmaceuticals: diclofenac, sulfamethoxazole, trimethorpim, carbamazepine and caffeine with a known concentration of 20 mg/L. Samples were exposed to a continuous stream of low-temperature plasma with a width of 8-10 mm. Contact times ranged from minutes to seconds, with the distance of the plasma jet from the liquid being 5 cm. The samples were analysed by high-performance liquid chromatography to determine the degree of elimination of selected pharmaceutical substances. It was found that removal efficiency of some pharmaceuticals was achieved up to 99,9%. These studies have indicated the great potential of using cold atmospheric plasma to remove selected pharmaceuticals from water using a highly economical and environmentally friendly advanced oxidation technology. To control the toxicity of the samples, toxicity tests were conducted to assess the possible effects of plasma treatment products on living organisms. Cold atmospheric plasma technology is a new advanced oxidation technology that incorporates the effects of free radical oxidation, high-energy electron radiation, hydrolysis under UV light and pyrolysis. It holds out hope for more efficient and less expensive removal of selected micropollutants from wastewater.

Keywords: atmospheric plasma; pharmaceuticals

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A new approach to treating wastewater from the coffee industry: A review of technologies and alternative solutions

On the global market, coffee is considered the second largest commodity after crude oil. The growing demand for coffee contributes to an increase in its production and the processing of coffee beans, leading to a rise in the quantity of wastewater generated. In the coffee production process, large amounts of water are consumed, which then becomes contaminated with compounds present in the processed coffee beans. The presence of toxic chemicals such as alkaloids, tannins, and phenols negatively impact the ecosystem. Additionally, the resulting wastewater is characterized by very high chemical and biological oxygen demand. This pollution has environmental implications, prompting the search for effective solutions to reduce the burden before discharge into the natural environment. The review analyses several methods (physicochemical and biological methods such as Photo-Fenton processes, UV radiation, chemical coagulation and flocculation, active sludge bioreactor, electrochemical methods, adsorption) for treating wastewater from coffee production, examining their disadvantages, advantages, etc. Alternative wastewater treatment options for coffee are also explored, including hydrophytic methods, bacteria and fungi. It is worth noting that the effectiveness of individual methods may depend on the chemical composition of coffee wastewater and environmental conditions. An optimal approach to treating coffee wastewater may require a combination of different methods. Research on coffee wastewater treatment should focus on both effectiveness and economic feasibility to enable commercial utilisation. The goal of this review is to provide direction for future research on integrated methods for treating wastewater from coffee production.

Keywords: coffee; coffee processing wastewater; sustainability; pollution; technology

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Sorption of mercury in batch and fixed-bed column system on hydrochar obtained from apple pomace

This paper presents the methodology for the preparation of hydrochar obtained from waste materials of natural origin and investigates its applicability for removing mercury ions from aqueous systems. The sorption properties of the obtained hydrochar were investigated in a batch and in a flow-through column system. The hydrochar material was obtained from apple pomace, which was hydrothermally carbonized in 230 °C for 5 h in a hydrothermal reactor. The hydrochar formed in the process was thermally activated with an inert gas flow—CO_2. Obtained materials were characterised with XRD, FTIR-ATR, SEM-EDS and nitrogen sorption (BET) analyses, which confirmed the obtaining of a highly porous carbon material with a specific surface area of 145.72 m^2/g and an average pore diameter of 1.93 nm. The obtained hydrochar was analysed for sorption of mercury ions from aqueous solutions. Equilibrium isotherms (Langmuir, Freundlich, Dubinin–Radushkevich, Temkin, Hill, Redlich-Peterson, Sips and Toth) and kinetic models (pseudo-first order, pseudo-second order, Elovich and intraparticle diffusion) were determined. The sorption of mercury ions from an aqueous solution with a concentration of C_0 = 100 mg Hg/dm^3 has been also carried out in a flow-through column system. The data obtained from adsorption were fitted to mathematical dynamic models (Bohart–Adams, Thomas, Yoon–Nelson, Clark, BDST and Yan) to illustrate the bed breakthrough curves and to determine the characteristic column parameters. The Yan model has the best fit across the study area, although the Thomas model better predicts the maximum capacity of the bed, which is q_{max} = 111.5 mg/g.

Keywords: mercury; hydrochar; sorption; column sorption system; waste materials

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Assessment of the effectiveness of removing selected pollutants from wastewater using sludge from water clarification from the Rudawa water treatment plant

The presentation shows issues related to the analysis of the impact of sludge formed during water treatment on wastewater treatment processes.

Until the 1980s, sludge from water clarification was discharged directly to receivers. Currently, due to increasingly stringent provisions and legal regulations regarding the quality and protection of surface water, sludge from water clarification, in accordance with the Waste Act, is included in the 19th classification group and assigned the code 19 09 02. This resulted in greater possibilities of using this waste in order to reduce the costs of disposal and seek rational use of waste. Sludge from water clarification can be used in construction and in sewage technology, conditioning of sewage sludge and in its processing processes.

The work focused on assessing the effectiveness of removing contaminants from leachate from the dewatering process of digested sewage sludge. Initial tests were carried out in portion tests with constant mixing. The volume of effluent samples was 200ml. The doses of sediments from water clarification used were: 1g, 5g, 10g. The assumed contact time of effluents with sediments was: 1h, 2h, 3h and 4h. During the tests, the following analyses were performed: COD, N-NH4 and P-PO4. Both in the tested samples and the control sample.

When analysing the COD, P-PO4 and N-NH4 indicators, attention can be paid to the decreasing tendency of the discussed parameters in the analysed samples with the increasing dose of sludge used from water treatment processes - for the given range of dose values. The influence of the contact time of effluents with sediments was also noted. The research carried out is preliminary, but it can be clearly stated that there is a potential for using sludge from water clarification in wastewater treatment processes.

Keywords: sludge from water clarification; wastewater treatment; recovery of raw materials; circular economy

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Assessment of the physicochemical properties of sand from sewage treatment plants in the context of use as fine aggregate in construction

Sand is a valuable natural resource, commonly used in the broadly understood construction industry, e.g., to produce various types of concrete and mortars, for carrying out earthworks, for construction works in buildings and road construction, or for winter maintenance of roads and sidewalks. It is estimated that as much as 30 billion Mg of sand is used annually in construction and due to the constantly developing infrastructure, the demand for this raw material is growing. Currently, sand is the third most valuable raw material in the world. Currently, there is no problem with sand deposits in Poland, but it is estimated that the problem with sand availability will appear in fifteen years and a critical situation will occur in thirty years. Therefore, it is now necessary to look for alternative solutions that will limit excessive, legal and illegal extraction of exhaustible, non-renewable sand resources. The aim of the research was to assess the possibility of using sand produced in the process of sewage treatment in construction. The research was carried out based on sand collected from a selected sewage treatment plant, which has a maximum daily throughput of 300 000 m³/d. As part of the project, physicochemical tests and leachability of selected harmful substances (P, F, N-NH_4^+, Cl, SO_4^{2-}) and heavy metals (Ba, Zn, Cu, Pb, Cd, Cr, Co, Fe, Ni) were carried out on three sands, that occur in the analysed object. The organic matter content was determined by roasting at combustion temperatures of 440°C, 600°C and 950°C. It was found that the loss on ignition (LOI in 950°C) did not meet the RILEM requirement for recycled aggregates (≤1%), as the content in all tested sands was at the level of 3%. By assessing the tested sands in terms of environmental impact, it can be concluded that the obtained levels of leachability of harmful substances and heavy metals do not pose a potential threat to the natural environment.

Keywords: sand; circular economy; reuse; recycling aggregate; construction

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Leaching of contaminations characteristics of municipal solid waste incineration fly ash

Thermal processing is one of the elements of the current municipal waste management. As a result of the thermal processing of municipal waste, secondary waste (fly and bottom ash, slag, dust from the dust removal system, etc.) is generated, which requires further management due to the negative environmental impact. Nowadays, the management of ashes poses a big problem related to the high concentration of contaminations which constitutes an environmental nuisance (heavy metals, chlorides, sulphates, etc). There are several ways to handle this type of waste, including storage of hazardous waste in the landfill, depositing in closed excavations of potassium salt, combustion in hazardous waste incineration plants and stabilisation. Fly ash after combustion of solid municipal waste contained mainly compounds of calcium (30.10%), silica (29.50%) and heavy metals (Σ8.67 g/kg). The paper will present test results of leachability of pollutants from fly ash of thermal transformation of municipal wastes. By applying stabilisation process it is possible to reduce dangerous compounds and the material obtained becomes safe for the natural environment. Such a form of the fly ash application corresponds to modern waste management with a closed circuit.

Keywords: waste; fly ash; utilisation; leachability of pollutants; immobilisation

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Analyses of self-consumption ratio of energy from photovoltaics in PV micro-installation - Poland Case Study

In the context of the current energy transformation, the use of energy from weather-dependent sources at the point of production is becoming increasingly crucial. This practice not only prevents overloading of the power grid but also enables the maximum utilisation of generated energy.

The utilisation of energy directly at the point of production is referred to as 'autoconsumption.' There are several methods to enhance the value of autoconsumption, with one of the most popular solutions being the use of electricity and heat energy storage.

A prosumer micro-installation was selected for analysis, and its annual operation was examined, taking into account the potential use of electricity storage with varying capacities and thermal energy. In the analysed micro-installation, the lack of any energy storage resulted in an auto-consumption coefficient of 30% (on an annual basis). Adding electricity storage with a capacity of 9 kWh would elevate the auto-consumption coefficient to over 60%. Furthermore, the incorporation of an additional thermal energy storage facility with a capacity of 5 kWh would enable an annual PV energy consumption rate of 80%. The analysis revealed varying impact of increase in the auto-consumption rate based on the quantity and type of energy storage implemented (thermal or electric).

Keywords: photovoltaic; self-consumption ratio; energy storage; heat storage; Poland

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Carbon Dots thermal synthesis from carbohydrates

Numerous methods have been developed to synthesise carbon dots (CDs). Presented studies were focused on synthesis by thermal degradation, which is method included in bottom-up syntheses. These usually starts from a simple carbon source which is a small molecule (i.a. glucose, citric acid, and amino acids), these molecules may be transformed to CDs through a multi-stage process of decomposition, polymerisation, condensation, carbonisation, and surface passivation with remaining small molecules.

The approaches taken by researchers to the process of synthesis CDs by thermolysis are diverse - there are investigations of synthesis from simple reagents as well as complex chemical substances; in solvent-free processes as well as with solvents; in the atmosphere of atmospheric air as well as with inert gases. The main objective of the presented research was to verify the possibility of synthesising CDs by solvent-free thermal decomposition in a muffle furnace, using as substrates various carbohydrates (fructose, starch, cellulose), which are present in biomass, which to the assumed extent has not yet been realized by scientists.

It was confirmed that the synthesis of CDs with emission spectra characteristics similar to each other is possible in a thermal process, using diverse carbohydrates in the synthesis. The fluorescence quantum yields of the obtained CDs are in the range of 0.2-3% (excitation λ=350 nm). CDs synthesized from starch were found to have the best fluorescence properties. This allows us to suppose that waste materials with relatively high starch content can be a good raw material for efficient, green synthesis of CDs.

Keywords: carbon dots; thermolysis; thermal degradation; carbohydrates

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The potential of using high-carbon bio-waste as raw materials for the synthesis of carbon quantum dots

The main objective of the research was to investigate the potential of high-carbon raw materials of natural origin for the synthesis of carbon quantum dots (CQDs). These particles are becoming an increasingly popular zero-dimensional nanomaterial with many applications in optoelectronics, environmental protection, medicine, or chemical engineering. Most often, pure chemical reagents such as simple sugars, amino acids, urea, and even polymers are used for their synthesis. The product was obtained using energy-efficient methods using homogenisation and microwave radiation. The syntheses were carried out using various process parameters (time, temperature) in a hydrothermal process in a microwave reactor. This does not cause additional costs and speeds up the process. The potential for use in the synthesis of CQDs was checked among such wastes as barley bran, rice bran, linen expeller, apple pomace and brewer's thresh. These raw materials contain 80-44% carbon, 16-50% oxygen, 3-9% nitrogen, and in the case of rice bran, about 2% of silica. The results were compared with the product of analogous syntheses based on D-(+)-Glucose (≥99.5%). The following analyses were used in the study: XRD, FT-IR, SEM-EDS, UV-vis spectroscopy, spectrofluorimetry, and DLS. The use of waste carries many advantages: compliance with the principles of Green Chemistry, reduction of waste in industry, and low price of production. The studies conducted show that the methods used as well as the raw materials allow the synthesis of CQDs with good fluorescence properties and small sizes. With the right process parameters, even better results can be achieved than for glucose-derived CQDs.

Keywords: carbon quantum dots; bio-waste; microwave synthesis; fluorescence; nanomaterials

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Energy in Green Deal

Parallel session

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Polish Energy Transition – combining energy security with sustainability and coal phase-out

Energy transition is a significant challenge for the European electricity sector, especially in the context of the energy and geopolitical crisis and energy security. The Polish energy sector, which is 79% dependent on coal is in a particularly difficult situation. In addition, the existing investment gap associated with the phasing out of the oldest coal-fired power plants will threaten energy security in Poland in the coming years, so a number of large investments in energy assets are necessary.

The purpose of this research is to present the Polish path of energy transition towards sustainability with regard to the energy security. Additionally, the SRMC (Short Run Marginal Cost) model depicts the margin costs of gas and coal-based power plants in terms of decarbonisation and re-shaping the energy mix.

Data sources included energy entities, public administration, GUS, Eurostat and energy databases. A linear SRMC model of all power units in Poland, operating as centrally dispatched units, was also carried out. It included coal-fired and gas-fired units. The SRMC model showed that the increase in natural gas prices resulted in gas-fired power plants being the most expensive units in the Polish system.

Severe increases in natural gas prices have resulted in a sharp rise in the price of electricity in Poland, which has become a significant driver of inflation. In line with the merit order mechanism, power units using natural gas with the highest SRMC received small margins, while entities using, for instance, hard coal or lignite recorded extraordinary profits.

Keywords: energy transition; sustainability; merit order; energy market; energy security

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Empowering the green deal through smart grids and microgrids for seamless renewable energy integration

This paper delves into the intricate technical details of smart grids and microgrids, examining their potential to revolutionize the water, raw materials, and energy sectors and drive the successful implementation of the Green Deal. It delves into the complex challenges associated with integrating intermittent and decentralized renewable energy sources into existing energy systems and elucidates how smart grids and microgrids can effectively address these challenges.

The paper explores advanced technologies, such as intelligent controls, real-time data analytics, and advanced communication systems, which empower smart grids to seamlessly integrate renewable energy sources into the existing grid infrastructure. Furthermore, it highlights the localized nature of microgrids, which operate independently or in parallel with the main grid, offering enhanced resiliency, flexibility, and the ability to optimize energy utilisation.

In addition to examining the technical aspects, the paper underlines the numerous benefits of employing smart grids and microgrids in the water, raw materials, and energy sectors. These benefits include improved grid reliability, reduced carbon emissions, enhanced resource management, and increased energy efficiency. The paper also delves into the strategies and approaches for widespread adoption, encompassing policy frameworks, regulatory incentives, and the importance of cross-sector collaborations.

To provide a comprehensive understanding, the paper analyses an array of best practices and successful case studies from around the world. These examples showcase how smart grids and microgrids have been effectively deployed to advance the Green Deal agenda, highlighting the role of policy frameworks, regulatory incentives, and cross-sector collaborations in accelerating the adoption of these technologies.

Keywords: smart grids; microgrids; renewable energy integration; green deal implementation; cross-sector collaborations

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Moroccan phosphate miracles: high-energy Na-ion battery solutions for a greener future

Sodium-ion batteries (SIBs) are gaining increasing attention as a promising alternative to lithium-ion batteries (LIBs) for grid-scale energy storage applications. This is due to the abundance and low cost of sodium resources. Among the key components of SIBs, cathode materials play a critical role in determining performance and overall cost. Phosphate framework materials have become an attractive option for electrode materials in SIBs due to their high structural stability, facile reaction mechanism, and rich structural diversity. In this review, we discuss recent advances in the exploration of phosphate framework materials, including fluorophosphates, pyrophosphates, and carbonphosphates. Additionally, we highlight the relationship between the materials' structure, composition, and performance. Furthermore, we examine Morocco's potential to leverage its rich phosphate resources for the development of a sustainable and economically viable energy storage industry. As one of the world's largest producers and exporters of phosphate, the research and development of sodium ion phosphate batteries in Morocco has the potential to promote the growth of the renewable energy sector and reduce dependence on fossil fuels.

Keywords: cathode materials; phosphate; sodium ion batteries; energy storage; batteries

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The impact of renewable energy technologies on personal welfare: environmental aspect

This study examines the multidimensional relationship between the adoption of renewable energy technologies and personal welfare from an environmental perspective. As the global community grapples with the pressing challenges of climate change and environmental degradation, the transition to renewable energy sources has emerged as a critical solution. However, there is a need to understand how this transition affects individual well-being, beyond the broader environmental benefits. The main objective of this study is to investigate the impact of renewable energy technologies on personal welfare, with a particular focus on environmental aspects such as reduced carbon dioxide emissions, improved air and water quality, and increased biodiversity. To achieve this, a comprehensive analysis has been carried out, integrating data from a wide range of scientific sources and studies assessing individual's quality of life. The results of study revealed several important findings. First, the deployment of renewable energy technologies is associated with significant reductions in greenhouse gas and pollutant emissions, leading to better environmental conditions. Second, people living in regions with higher penetration of renewable energy technologies reported better overall well-being, including better health indicators and a greater sense of care for the environment. In conclusion, the research underscores the pivotal role of renewable energy technologies in shaping personal welfare through their positive environmental impact. As societies increasingly shift towards renewable energy sources, policymakers and stakeholders should consider these findings to promote the well-being of individuals while addressing environmental challenges. This study contributes valuable insights into the ongoing global transition to sustainable energy systems and underscores the importance of sustainable energy policies in enhancing personal welfare and safeguarding the environment.

Keywords: renewable energy; renewable energy technology; energy transition; personal welfare

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Legal aspects of protecting the energy security of Member States and EU citizens based on the judgment of the Court of Justice of the European Union in case C-848/19 P and EU primary law

The energy transformation, inevitable from the point of view of environmental protection, encounter a number of technical, economic and legal problems. In the context of the latter two, the circumstances related to the sustainable and just transformation proposed under international agreements (including the Paris Protocol) are widely discussed.

The main objective of this paper is to define the role of the sustainable development principle of EU primary law in striving to ensure legal protection during the energy transition. The research question is whether, and if so, how can Member States and individuals in the EU assert their rights to ensure energy security? The scope of the paper is limited to analysis of EU primary law (TEU, TFEU, Charter of Fundamental Rights of the EU), the case law of the Court of Justice Of the European Union (cases: C-848/19 P, T-883/16, 26/62, 25/62 and C-583/11) and legal doctrine. The analysis was carried out using the legal-dogmatic method. As a result of analysis it was found that:

(a) energy security is booth condition and goal of sustainable development principle so it is part of this principle, but human right to energy is contradictory to this principle;
(b) the EU legal order allows the assertion of rights of EU Member States and individuals in front of CJEU taking as its legal basis the principles of EU law.

These results lead to a conclusion that first part of research question is answered positively, and second part is answered as follows: in EU energy security is protected as part of legal principle of sustainable development and within solidarity principle.

Keywords: energy security; green transition; European Union; sustainable development; legal principle

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Green energy for enterprises

Polish enterprises face the need to carry out an energy transformation covering all processes related to their operations. On the one hand, the changes are determined by the ambitious plans of the European Commission, which in the Fit for 55 package assumes reducing CO2 emissions by 55% compared to 1990, increasing energy efficiency to the level of 36-39%, as well as increasing the share of renewable energy sources in production. energy up to 40%. On the other hand, the CSRD on Sustainability Reporting extends the obligation to report non-financial ESG to additional companies. The main goal of the paper is to identify the most important projects aimed at improving energy efficiency in enterprises and, if possible, investing in renewable energy sources. The process of decarbonising an enterprise is both complex and expensive. However, considering the constantly rising costs of electricity and the increase in its consumption, the energy transformation of the company must be included in its long-term operational strategy. Moreover, the paper will present various types of renewable energy sources used by enterprises (own installations, PPA contracts, planned direct line). The use of renewable energy sources by enterprises may significantly contribute to gaining a competitive advantage and implementing the principles of sustainable development. Initially, high investment outlays incurred in connection with the installation of renewable energy sources are compensated by low costs of operating the installation in the later period and a quick return on investment.

Keywords: renewable energy sources; energy transformation; energy efficiency; green energy; ESG

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Resource-efficient and low-carbon heat energy production in the small-scale energy sector

The climate change mitigation agenda in Lithuania aims to reduce greenhouse gas emissions (GHG) by 25% in a small-scale energy sector by 2030 compared to 2005; also the share of RES in the total balance of final energy consumption should be 45%. The aim of this study is to evaluate situation in Lithuanian small-scale energy sector and provide optimisation alternatives for resource-efficient and low-carbon heat energy production by applying Cleaner Production methods.

The object of the study is a small-scale energy company providing heat energy supplying services, which operates in the municipality of Kretinga district (area - 989 km^2, population - 37.6 thousand) and serves 25 small boiler houses with a total thermal capacity of 65.154 MW. In 2022, more than 42 GWh of thermal energy were produced in all combustion plants of the company, incl. more than 88% due to the combustion of woody biomass. It was estimated that the direct and indirect impact on climate change due to GHG is up to 0.042 t CO_{2e}/MWh. The Cleaner Production assessment determined that the efficiency of energy production in the smaller boiler houses is quite low (≈ 80%). The introduction of condenser economizers will allow increasing efficiency and reducing fuel consumption by 17%. Another alternative is to abandon the natural gas combustion process and implement air-water heating pumps; this will reduce fuel consumption by 43%. This alternative is especially attractive if the combustion plant uses electricity from RES. In this case, the reduction in GHG emissions will reach 86%.

Keywords: resource efficiency; cleaner production; CO_2 reduction.

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Tandem (transdisciplinary and deliberative equity appraisal of transition policies in energy and mobility) - project introduction. Participatory pathways for the co-design of energy policies by example of Krzywcza municipality

TANDEM (Transdisciplinary ANd Deliberative equity appraisal of transition policies in Energy and Mobility) project introduction. Participatory pathways for the co-design of energy policies by example of Krzywcza Municipality.

The aim of the presentation will be to introduce the assumptions of the TANDEM project (Transdisciplinary ANd Deliberative equity appraisal of transition policies in Energy and Mobility) which has been launch in October 2022 in the “The Division of Minerals and Energy Sustainable Development” lab in IGSMiE PAN.

In order to present the aim of the project, it will be important to highlight the research context. Here, both the institutional aspect (Horizon Europe project), the theoretical basis (sociology of knowledge) and the socio-political aspect (tensions arising from the energy transition and the climate crisis) will be presented.

This is followed by a presentation of the scientific objective of the project, which is "development of transdisciplinary approach to identify and analyse emerging inequalities of low-carbon transition policies and co-design equitable, just and effective alternative transition pathways with stakeholders". This essential part of the talk will also introduce research design hidden in the TANDEM project.

In the course of the paper, I will talk about the five case studies explored in the project, which are: the clean transport zone in Brussels; thermo-modernisation of housing estates in Innsbruck; peat production in northern areas of Finland; energy cooperatives in Catalonia.

I will devote most attention to the issue of switching away from fossil fuels in rural households on the example of the municipality of Krzywcza (Podkarpackie voivodeship). The presentation will give the basic demographic and economic data characterising the municipality of Krzywcza and the structure of the energy mix used by its households.

Keywords: energy policies; citizen participation; citizen-based policy; “from black to green”

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Summary

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Water in Green Deal Strategies: from intake to recovery

Since the 1960s, the water demand has more than doubled. The increased demand is related to the ever-growing global population and economic development, particularly agriculture, animal husbandry, and energy production. Additionally, the intensification of the effects of climate change will affect the quality and quantity of water resources. According to World Resources Institute data, 2/5 of the population currently lives in areas at risk of water shortages. Moreover, this number will increase dramatically in the future, deepening the global water crisis. It is estimated that by 2050, 100% of the population of North Africa and the Middle East will live in conditions of extreme water scarcity.

Moreover, the proportion of the world's population exposed to salinity, organic pollutants, and pathogens will increase by 17 to 27%, 20 to 37%, and 22 to 44%, respectively, by 2100, with poor water quality disproportionately affecting developing countries. Therefore, further technological development and, effective laws protecting the most valuable water resources, and increased water recovery from sewage are necessary. But also solidarity financial and technological support from the countries of the Global North. We can only achieve the Sustainable Development Goals through extensive cooperation between scientists from all over the world. The International Conference Strategies toward Green Deal Implementation Water, Raw Materials & Energy fits this idea very well, providing researchers with a platform for exchanging knowledge and experiences.

Keywords: water treatment; water crisis; climate change; water scarcity; water recovery

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Poster session

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Social campaigns raising public awareness of the importance of water - waterCEmanagement project

Water is a fundamental resource that plays an important ecosystem role. For many years, the European Commission (EC) emphasis its importance by presenting documents, directives and regulations aimed at the protection and sustainable management of water resources. Their effective management is of fundamental importance and requires a holistic approach, involving various stakeholder groups. Sustainable water management projects are a key pillar of global efforts to maintain ecological, economic and social balanceto secure this key resource for current and future generations.

Paper presents educational and information activities carried out as part of an international project "waterCEmanagement in practice - developing comprehensive solutions for water reuse and raising awareness of the key role of water in the transformation process towards a circular economy (CE)". One of main project objectives is dedicated to raising the ecological awareness of society in the field of rational management of water resources. To achieve this, the Polish-Norwegian consortium implements a comprehensive promotional campaign sustainable water management. Shaping ecological awareness through the ecological education requires various forms and methods, depending on the type of participants. In this paper, trainings, workshops, seminars and summer schools for various stakeholder groups, are indicated as effective methods of building ecological awareness in Poland. Due to the coronavirus pandemic affected the transfer most of the courses (both theoretical and practical) into a virtual forms, we point out a strong need to provide forms and methods of ecological education that are effective conducted online. Further development of various forms of ecological education related to water can be expected, due to the EC's recommendation in this regard.

Keywords: water; education; ecological awareness; social ecological awareness

Acknowledgments: Paper prepared as part of the project "waterCEmanagement in practice - developing comprehensive solutions for water reuse and raising awareness of the key role of water in the transformation process towards a circular economy (CE)" which uses funding worth 323 549,34 euro received from Iceland, Liechtenstein and Norway under the EEA Funds. The aim of the project is to strengthen the transformation towards a circular economy in the field of circular water resources management.

Iceland Liechtenstein Norway grants

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Degradation of Isoprinosine in two different water metrics by Solar-Light Driven process

The objective of this research was to examine degradation of isoprinosine (IPN), an antiviral medication that can be used to treat COVID-19 in outpatient settings in two different water metrics, such as milli-Q and Tap water. The study was conducted at ambient conditions. A concentration of 2.0 mg/L IPN was utilized, with 500 W/m^2 solar irradiance, and photocatalysts such as TiO_2─P25 and ZnO were used. The concentration of IPN was monitored by HPLC at a wavelength of 260 nm, and the photocatalysis of IPN followed pseudo-first-order kinetics. The highest value of the pseudo-first order rate constant of photodegradation of IPN was recorded for photocatalysis with 20 mg/l TiO_2─P25 and it was equaled to 0.0483 min^{-1} in MQ water with R^2=0.9268. The study also evaluated the effect of photocatalyst doses and initial IPN concentrations on the photodegradation of IPN efficiency. Studies have shown that IPN is resistant to degradation under the influence of sunlight (9% after 2 h of the process), and (16% after 2 h of the process) in milli-Q and tap water, respectively. The addition of selected photocatalysts allows the breakdown of the IPN molecule. Between the tested photocatalysts, TiO_2─P25 was particularly promising. The study also discovered that IPN partially adsorption to TiO_2 particles (33% after 2 h), and ZnO particles (26% after 2 h). Based on the results, solar-light-driven photocatalysis, after optimisation of the process, may be a promising technique for the degradation of selected antiviral drugs in environmental metrics.

Keywords: isoprinosine; solar light degradation; photocatalysts; AOPs

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Biochemical methane potential of grass waste and fruit and vegetable waste: investigating the influence of size reduction and the mixture ratio

Using grass waste (GW) from natural areas, roadside, or golf course management represents a promising feedstock for anaerobic digestion. This study aims to optimize the efficiency of grass waste management within the bio-circular-green economy framework by exploring its co-digestion with fruit and vegetable waste (FVW). The Biochemical Methane Potential (BMP) test, a widely employed technique for assessing the methane generation potential of substrate mixtures, was conducted. Raw grass underwent a size reduction pre-treatment.

In a series of batch assays conducted under mesophilic conditions for 30 days, both raw and pre-treated grass (GS) were combined with FVW in varying proportions (100:0, 80:20, 60:40, 20:80, and 0:100, on a total solid basis) to identify co-substrate synergism. The first-order kinetic model and two-fraction first-order (TFFO) kinetic model were employed to assess the kinetic behaviors of the different substrates.

The experimental BMP results revealed that FVW exhibited a more significant methane generation potential at 453.32 $NmlCH_4\ g_{VS}^{-1}$ compared to raw GS_r and treated GS_t, which produced 163.43 and 174.02 $NmlCH_4\ g_{VS}^{-1}$, respectively. Notably, no synergistic ratio above unity was observed. However, the size reduction significantly enhanced the degradation kinetics of grass waste. The results demonstrated that the TFFO model fit well with the experimental data, exhibiting the highest R^2 values (0.993–0.999) and the lowest RMSE values (1.37 - 8.81).

In conclusion, these findings will guide the subsequent continuous co-digestion of grass waste with fruit and vegetable waste (FVW).

Keywords: biochemical methane potential; grass waste; fruits and vegetable waste; size reduction; kinetic models

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Study on the 1-methyl-3-octylimidazolium chloride recovery by electrodialysis method

The 1-methyl-3-octylimidazolium chloride ([O_{mim}]Cl) is an example of the imidazole based ionic liquid (IL) with a melting point below 100°C. The imidazole based ILs due to their unique physical and chemical properties such as high conductivity, high thermal stability, and ability to solubilize many inorganic and organic compounds can be applied in various industries. The [O_{mim}]Cl can be used for example in the hydrolysis of sucrose, and as catalyst of reactions or in the purification and extraction of biomolecules. However, the very good miscibility of ILs with most solvents caused that their recovery by classical separation techniques can be inefficient. One of the promising methods of the ILs recovery from wastewaters is electrodialysis (ED).

The objective of this work was to evaluate the effectiveness of the [O_{mim}]Cl recovery from aqueous solutions by ED method. The effects of initial [O_{mim}]Cl concentration (0.01 M – 0.15 M), applied voltage (5 - 10 V), and linear flow velocity (1 - 3 cm/s) were investigated. The ED experiments were carried out using an EDR-Z/10-0.8 module (MemBrain, Czech Republic) with an effective membranes area of 320 cm^2. The membranes used in the experiments were AM-A and AM-C (Ionsep, China). The recovery of the [O_{mim}]Cl, the [O_{mim}]Cl molar flux across ion-exchange membranes, the concentration degree, the current efficiency, and the energy consumption were determined.

It was noted that the [O_{mim}]$^+$ flux, and the [O_{mim}]Cl recovery increased with increasing concentration of [O_{mim}]Cl. It was found that ED with heterogeneous AM-A and AM-C (Ionsep, China) ion-exchange membranes allows for the recovery of over 85% of [O_{mim}]Cl from aqueous solutions. It can be concluded that, ED can be applied as a promising method of the [O_{mim}]Cl recovery from aqueous solutions.

Keywords: ionic liquids recovery; 1-methyl-3-octylimidazolium chloride; electrodialysis

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Removal microplastics from water – technological advances and green strategies

Microplastics (MPs) are globally widespread in aquatic environments and are becoming a growing threat to the ecosystem. The development of effective technologies to remove MPs from water is urgently needed. The progress of the main technologies for removing MPs from the aquatic environment is presented, including physical, chemical and biological methods. Filtration technologies have varying removal efficiencies, relatively high cost due to fouling of filter baffles, mainly semi-permeable membranes, and frequent replacement. Adsorption and magnetic separation approaches are simple removal methods; however, sorbents can cause secondary contamination. A similar problem of secondary fouling occurs in treatment by coagulation and oxidation methods. Biodegradation and bioreactors, on the other hand, often have low microplastic degradation efficiencies. A comparative analysis of existing microplastics removal technologies in aspects of removal efficiency and environmental impact confirms all the disadvantages of methods used in water and wastewater technology. Green strategies to combat plastics are proposed, including zero-emission removal technologies, integrated environmentally friendly approaches, recycling the use of conventional plastics and the development of biodegradable plastics in the future.

Therefore, more efforts are needed to develop cost-effective and highly efficient abatement technologies for removing MPs. Green strategy and environmentally friendly technologies should be reinforced, and gradually be applied at large scales. As green strategies in the removal of microplastics from water can be mentioned: coagulation, magnetic separation, catalysis and photocatalysis and biological methods as membrane bioreactors.

Keywords: microplastics; removal methods; green strategy

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Agricultural use of fertilizers based on sewage sludge and the presence of pharmaceuticals - risk assessment

The processing of wastewater in fertilisers is one of the innovative ways to manage wastewater sludge. The detection of pharmaceuticals in them prompts research on the presence of drugs in fertilizers based on sludge. The main goal of the research was to evaluate the risk of a negative impact of fertilisers on the natural environment. Bactericidal, virucidal and fungicidal drugs were determined in sewage sludge and fertiliser.

12 samples of sewage sludge and fertiliser samples were analysed. All samples were lyophilized and subjected to extraction by QuECheRS and LC-MS/MS analysis. In sludge, similar to fertilizers, the presence of 16 substances was detected and 12 were determined. A leaching test of fertilisers into the soil was also carried out to simulate the reactions and potential fate of pharmaceuticals in the soil. The overlying liquid generated in the elution test was subjected to chromatographic analysis. Only 5 compounds were determined in the tested solution, which means that the remaining ones are not released into the aquatic environment or decompose.

For compounds that leached into the aqueous phase in the leaching test, the Risk Quotation coefficient was calculated, the value of which determines the risk of negative changes in the environment. The results showed that linezolid and ofloxacin/levofloxacin do not give reasons to expect negative changes in the environment, and the presence of isoniazid and/or sulfapyridine in fertilizer reduces the risk of changes in the soil. However, the negative effects of their impact should be taken into account.

Keywords: sewage sludge; fertilizer; sewage sludge management; pharmaceuticals; risk assessment

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Biogas production from willow leaf sunflower and dairy manure during anaerobic digestion

Anaerobic digestion of lignocellulosic residues, as well as agricultural waste by mixed cultures, is a very promising biological process for producing biologically and efficiently biogas. The aim of the study was to determine the biogas production from willowleaf sunflower and cattle manure during mesophilic anaerobic digestion (39°C) in semi-continuously fed and fully stirred tank reactors (CSTRs) with a working volume of 6L each. The experiments were carried out for the single substrates willowleaf sunflower (series 1) and cattle manure (series 2) and their mixtures in the VS ratios 93.75:6.25 (series 3) and 87.5:12.5 (series 4). The organic loading rate (OLR) in all series was 6 g/L·d, and the hydraulic retention time (HRT) was 15 days. The results showed that the highest biogas production was obtained for cattle manure alone (5.29 L/d), followed by series 4 with 12.5% (g VS) content of dairy manure in the mixture (4.92 L/d), and series 3 with the content of dairy manure 6.25% (g VS) (2.85 L/d). The lowest biogas production was obtained for willowleaf sunflower alone, equal 2.57 L/d. Accordingly, the highest biogas production rate, equal 0.88 L/L·d was obtained for dairy manure alone, and the lowest 0.43 L/L·d, for willowleaf sunflower alone. In conclusion, the biogas production depends on the substrate type. Among all substrates and their mixtures dairy manure is emerging as a promising source for efficient biogas generation.

Keywords: biogas production; energy crops; anaerobic digestion; willowleaf sunflower; cattle manure

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The solar energy – the economic and environmental effects of photovoltaic systems

This study aims to determine the economic and environmental effects of photovoltaic (PV) installation over 30 years of lifetime. The economic assessment was performed for two PV variants (V) that differ in the power of the installed systems (V_1 = 5 kW and V_2 = 8 kW). As a reference variant (V_0) the total energy cost was calculated. The net present value (NPV) of both variants are economically effective (NPV_V_1 = 3 580 Euro and NPV_V_2 = 6 270 Euro) with discounted payback period (DPP) equalled 9.5 and 7.9 years for V_1 and V_2, respectively. The environmental effect was calculated as an equivalent of CO_2 avoided emissions. Thanks to the use of PV, it is possible to avoid the annual emission of carbon dioxide into the atmosphere resulting from the combustion of coal in conventional power plants of 4705 Mg/year, which can be absorbed by 1045 ha of forest. Also, the total life cycle emission in the case of PV system is 23 and 11 times lower than nonremovable sources of energy such as gas and coal. Both the economic and environmental effects of PV installation are positive. However, it must be kept in mind that other PV aspects such as recycling and utilisation were not considered in this study.

Keywords: CO_2 absorption; economic assessment; environmental effect; NPV

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Monitoring the development of the hydrogen economy: insights from the European context

Hydrogen has risen to prominence as a key factor in the European Union's transition to climate neutrality by 2050 and reducing dependence on fossil fuels. Considered by many as a game changer, hydrogen is reshaping the energy system and holds a central role in fostering sustainable energy practices. Despite the European Union's commitment to evidence-based policymaking, a thorough proposal for monitoring the progress of the hydrogen economy (HE) across the entire value chain remains noticeably lacking.

This study addresses this research gap by proposing a set of indicators to assess HE performance, with a particular focus on individual links in the hydrogen supply chain. An analysis of the hydrogen strategies of the Member States of the European Union as well as the United Kingdom and Norway was carried out. A total of 124 potential indicators are presented, covering different stages of the supply chain, encompassing feedstock, production, transmission, storage, distribution, and end users. The authors also point out differences due to the diverse objectives of individual policies and hydrogen applications in various sectors.

This study significantly improves the tools for monitoring the progress of the HE in Europe. Decision makers, including local and regional authorities, can use this inventory of benchmarks to analyse the transition to the HE. In addition, the proposed metrics are likely to be included in future updates of hydrogen strategies.

Keywords: hydrogen economy; monitoring framework; indicators; strategies; European Union

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Role of Fe(II) as reductant agent in lithium-ion batteries recycling

Recycling lithium-ion batteries (LIBs) has gained attention recently due to the growing demand for electric vehicles and portable devices. The recycling processes have been developed based on metallurgical techniques, which typically treat the battery wastes with mechanical and thermal pre-treatment to facilitate the dissolution via acid leaching. Adding a reductant agent in the leaching system is a crucial factor in leaching efficiency due to the presence of insoluble metals in the solid, such as Co^{3+} and Mn^{4+}, which need to be reduced to a lower oxidation state. H_2O_2 is the most common and predominant reductant in the LIBs recycling industry due to its oxidation does not release new ions to the system. However, the current process to produce H_2O_2 is costly and not environmentally sustainable. Hence, the search for alternative reductant agents should be addressed.

This work studied the effect of Fe (II) as a reductant agent in the leaching process of LIBs cathodes. Batch extractions were carried out using samples of commercial $LiCoO_2$ solid and real LIBs waste ($LiMn_{1.4}Ni_{0.2}Co_{0.05}O_x$). Different parameters such as Fe(II) dosage, time reaction and pH value were evaluated. Under the optimal experimental conditions (50g/L; 2M HCl; 1M Fe(II)), the extraction yield was approximately 100% for Li and Co from $LiCoO_2$ as well as almost 100% of Li, Mn and Ni from $LiMn_{1.4}Ni_{0.2}Co_{0.05}O_x$. According to the experimental results, adding Fe(II) enhances the extraction yield, confirming its role as a promising reductant agent for metal recovery.

Keywords: recycling; hydrometallurgy; reductant agent; e-waste; circular economy

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Circular Economy – discussion of upcoming changes based on the example of plastic beverage packaging

Recent years have shown a progressive change in society's awareness of caring for the environment, which translates into companies' actions aimed at better resource management and causes pressure to transition to a Circular Economy (CE). What actions do companies take to better design, produce and recycle their products? The primary purpose of this work is to present the changes taking place during the transition to the circular economy using the example of plastic beverage packaging.

The data was collected from materials published on the Internet and from companies that agreed to share them. Based on the collected information, the main disadvantages of the linear economy were identified, and the advantages related to the transition to a CE were indicated. Aspects affecting both the economy and the end user were examined. It was determined what benefits a change in the approach of enterprises and households may bring.

The benefits of this change have been demonstrated. Reducing the weight of packaging by 25% and reducing water use by 15% in the production of plastic packaging. These changes are expected to take place already in 2025. Knowing how huge the production market is for plastic beverage packaging, changes towards the use of more environmentally friendly materials such as rPET or the design of environmentally friendly labels provide opportunities to produce 100% recyclable packaging.

Keywords: sustainable environment; circular economy (CE); 3R; 6R

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Evaluation of water loss performance indicators: towards the implementation of Directive (EU) 2020/2184

Leaks causing water losses in water distribution systems (WDSs) are responsible for approximately 24% of water consumption in the European Union (EU). The Drinking Water Directive of the European Parliament and the EU Council (Directive (EU) 2020/2184) introduces the obligation of reporting the water losses by water supply companies in EU. The indicator recommended in Directive (EU) 2020/2184 is infrastructure leakage index (ILI) which is ratio of current annual real losses (CARL) to unavoidable annual real losses (UARL). Paper presents the comparative analysis of loss performance indicators calculated for 3 Polish WDSs. Results show that values of different indicators calculated for specified companies in certain year were diversified. The highest correlation was obtained between ILI and the normalized real leakage balance expressed in dm^3 per service connection per day (RLB_2). Weaker correlation was observed between ILI and the non-revenue water (NRW) expressed as a percentage of water supplied to the network. Results show that the comparative analysis of different systems based on various indicators is not reliable. Authors postulate that regulations should specify indices which should be used by companies to assess water losses if the ILI determination is not possible. Normalized real loss indicators related to the unit of length of mains or the number of service connections can be examples of suitable indicators. Correct assessment of the WDS condition is very important because obtaining the acceptable but incorrect values of water loss performance indicators may result in the abandonment of activities aimed at reducing water leakages.

Keywords: water losses; water distribution system; real losses; infrastructure leakage index (ILI); Directive (EU) 2020/2184

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Development of coastal building eco-materials with a high sustainability from industrial by-products

The present work explores the transformative potential of geopolymer materials in enhancing the sustainability and resilience of marine infrastructure. Coastal regions, historically centers of human activity, face escalating challenges due to erosion, saltwater corrosion, and extreme weather events. Geopolymers, as innovative building materials, present a promising solution to these issues, offering exceptional durability, reduced environmental impact, and versatile applications in marine construction.

A framework approach is used to examined the geopolitical, environmental, socio-economic, and technological intricacies inherent in marine construction. Geopolitical issues encompass territorial disputes and international cooperation, while environmental challenges range from erosion and pollution to climate change impacts and hazardous materials. Socio-economic complexities arise from the delicate balance between economic growth, cultural preservation, and community well-being, and technological demands require continuous advancements for structural resilience. Following these findings comes the term geopolymer as a sustainable alternative, showing their outstanding features to reduce environmental impact, enhanced structural performance, and adaptability for diverse applications. Geopolymers, derived from industrial by-products, contribute to waste reduction, lower carbon emissions, and prolonged service life in marine structures. In the other hand, the interdisciplinary nature of geopolymers involves collaboration across material science, engineering, environmental science, and chemical engineering, offering a multi-disciplinary impact with applications in construction, waste management, and marine engineering.

The solutions and mitigation strategies proposed, emphasising the alignment of economic prosperity, societal well-being, and environmental sustainability. The plan includes also, advocating for government support, standardisation, market development, and community engagement. In fact, the geopolymer innovative approach advocates for a holistic paradigm shift in marine construction, where these materials not only revolutionize traditional methods but also foster a sustainable, economically viable, and environmentally conscious future. The proposed strategies provide a roadmap for seamlessly integrating geopolymers into marine infrastructure, ensuring a harmonious coexistence with coastal environments.

Keywords: geopolymers; building materials; sustainability; innovative; marine construction

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Expanded perlite – material of the future

The search for new materials that combine multiple features is driven by the need for sustainable solutions, resource efficiency, energy savings, performance requirements and changing market demands. Modern building material design should take many factors into account. Could expanded perlite be such a material, combining many often non-obvious properties and characteristics?

Applications of expanded perlite are very wide from horticulture and agriculture, industry and construction to the more non-obvious ones such as animal bedding or antibiotic carrier, in order to identify the development directions with the greatest potential.

Overall, the important issue is the potential use and benefits of perlite in various applications. However, some studies also highlight the need for caution and proper protective measures when handling perlite to avoid potential adverse effects.

The aim of the study was to analyse the results of the experimental determination of the basic physical, mechanical and chemical parameters of perlite concrete blocks. The focus was on determining the compressive strength, thermal conductivity, chemical composition and environmental impact. Above parameters allow to determine the applicability of this material in civil and environmental engineering and further research directions.

Keywords: sustainable construction; natural building material; perlite; mechanical parameters

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Green roof - a solution for the future or a construction problem?

The presented research problem concerns the analysis of the causes of damage of green roof coverings. The obtained research results constitute a preliminary stage for the development of new solutions of roof coverings, which could perform the function of increasing the biologically active surface in urbanised areas without fail. The mechanism of operation of roofs made in traditional layouts, in which waterproofing layers are laid on the surface of thermal insulation layers and in inverted layouts, in which the thermal insulation is not surface covered against water penetration, were analysed. In both cases, the damage mechanism is different. In inverted roofs, the main damage factor is the passage of outdoor temperatures through 0˚C, leading to moisture in the thermal insulation. Results of laboratory tests showed that in this case, total immersion in water for 28 days of the thermal insulation panels (i.e. extruded polystyrene - XPS and surface insulated EPS) has a negligible effect on the increase in moisture content, while freeze-thaw cycles contribute to an almost 10-fold increase in moisture levels. In contrast, in the case of green roofs with traditional layering, the integrity of the waterproofing layers is threatened by overgrowing plant roots. In both cases, the repair of the above-mentioned damage to green roofs results in the necessity to carry out repair works involving the replacement of both thermal and waterproofing layers, which in turn poses the risk of creating heaps of construction waste. The results of the research allowed further directions to be set for the development of roofing layer systems on green roofs, eliminating the above-mentioned risks.

Keywords: green roofs; laboratory test; damage to waterproofing and thermal insulation layers

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Biosorption of zinc from municipal and industrial wastewater by algae

In studies on the removal of Zn(II) from municipal and industrial wastewater (from the coking and galvanisation industries), algae from the outflow channel of a municipal sewage treatment plant and pure algae cultures: Chlorella vulgaris and Scenedesmus armatus from the CCBA collection of Baltic algae cultures were used. Freely suspended, calcium alginate-immobilised Chlorella vulgaris cells and hollow alginate beads were used. Experimental data showed that the biosorption capacity of algal cells was dependent on operational conditions such as pH, dose, contact time, and temperature. The maximum biosorption of Zn(II) for galvanisation wastewater was achieved with mixed algae culture (dead immobilised) for the highest dose (3g/l) and amounted to 88%. Biosorption of zinc(II) ions from coke wastewater was at the highest level for a dose of 3 g/l for free-swimming live individuals (79%) and immobilised Chlorella vulgaris cells (69%). It was found that the degree of zinc(II) removal from municipal sewage was not dependent on the biosorbent dose, because the values obtained for individual cases did not differ significantly from each other. The highest efficiency was obtained for immobilised live Chlorella vulgaris cells (74%). The lowest biosorption was observed for Scenedesmus armatus. It was found that for the highest dose of biosorbent for immobilised living algae cells, zinc biosorption was 46%. For all types of wastewater tested, it was observed that increasing the pH resulted in better biosorption of zinc(II) ions. Similar biosorption values (70±5%) were observed in municipal and galvanisation sewage for Chlorella vulgaris immobilised biomass at pH = 7.0.

Keywords: municipal wastewater; zinc; coke wastewater; galvanisation wastewater; freely suspended Chlorella vulgaris cells; immobilised Chlorella vulgaris cells; Scenedesmus armatus

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Controlled delivery of active substances through the use of hydrogels

Quite frequent problem in drug and active substance delivery is a rapid release from the carrier systems which may adversely affect their therapeutic effects. The objective of this work was two-fold: (1) to investigate experimentally the possibility of releasing active substances from hydrogel-based carriers (2) to evaluate the potential of hydrogels to encapsulate and efficiently deliver hydrophobic anti-cancer drugs from the taxane class. Thus, the work is divided into two parts presenting (1) experimental data and (2) literature review results.

The experimental part focuses on encapsulation and release of vitamin C and plant extracts from a chitosan and polyvinylpyrrolidone hydrogel-based delivery systems. The release of active compounds to the Ringer's solution was followed by pH measurements. FT-IR and microscopic examination of incubated and non-incubated samples were performed, showing differences in the structure of the hydrogels, indicating a gradual release of active substances.

The literature review on the application of polymer-based hydrogels in taxane drug delivery was performed. It has been found that rarely, hydrophobic drugs like taxanes can be incorporated in hydrophilic hydrogels without prior encapsulation in amphiphilic nanocarrier systems. The hydrogel systems were composed of natural and synthetic polymers.

The results lead to the conclusion that hydrogels are versatile materials that can be applied to control the release of both hydrophilic and hydrophobic drugs. They show a great potential in combating various therapeutic challenges e.g. premature absorption of taxane anticancer drugs from the peritoneal cavity and thus to enhance the effectiveness of the drugs and diminish systemic toxicity.

Keywords: hydrogel; drugs; active substances; polymers; controlled delivery system

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Automated formulation of 3D Concrete Printing mixes

Three-dimensional concrete printing (3DCP) has rapidly evolved in recent years, finding new applications and gaining recognition as a mature, viable industrial technology. This building technique is based on layer-by-layer deposition principle utilising a wide range of concrete or other cementitious materials. As a novel approach, it offers unprecedented flexibility and performance within the construction industry. Furthermore, 3DCP appears as an opportunity for reduction of material waste and energy consumption when compared to traditional methods. The main objective of the presented poster is to provide basic information on 3DCP material production for on-site applications. Moreover, some of the current challenges in the area of concrete mix design and preparation for the printing process are detailed, including aspects of large scale solutions. This brief study covers various factors such as speed and efficiency of set-up and production of the extrusion material also considering overall cost-effectiveness and prospects for its future improvements. Other outlined insights render the potential for 3DCP to not only minimise construction costs through automation and increased efficiency but also to significantly reduce the carbon footprint associated with structure creation.

Keywords: 3DCP; concrete 3D printing; 3D concrete mix

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Membrane processes as a part of the treatment of rainwater and stormwater for recreational use

The United Nations General Assembly (UNGA) Sustainable Development Objectives, notably Goal 12 regarding eco-friendly consumption and production, call for investigating methods for safeguarding existing raw materials, including water resources. One of the possibilities for rational management of water resources is the use of rainwater in areas where only tap water has been used so far. An example is the use of rainwater in recreational objects like swimming pool facilities. The aim of the undertaken studies was to assess the rainwater quality after the treatment using membrane processes. The rainwater used in this study was collected from the roof of a sports facility located in an urban area in Upper Silesia. The filtration process was conducted using a semi-industrial installation TMI 14 from J.A.M INOX Produkt, which was equipped with a tubular flow-through membrane module with a polyamide membrane AFC30 or AFC80 from PCI Membrane System Inc. (USA). The membrane filtration process was performed until 20% of the feed was collected at a transmembrane pressure of 2 MPa. The obtained results were compared with the quality requirements for drinking water (Dz.U. 2017 poz. 2294) and swimming pool water (Dz.U. 2022 poz. 1230), as an example of the recreational use of this water stream. Furthermore, the rainwater was analysed both before and after the treatment, using a gas chromatograph equipped with a mass detector, which enabled the identification of existing organic micropollutants, which could be detrimental in the event of direct contact with individuals. The obtained results indicated that the tested rainwater contained micropollutants belonging to various groups of compounds. Therefore, it should be subjected to in-depth treatment before its future use. The nanofiltration process carried out at the AFC80 membrane allows to obtain water quality parameters similar to tap water. This makes it possible to use purified rainwater in swimming pool facilities. However, the implementation of membrane processes in the treatment of rain or stormwater creates another challenge related to the proper treatment of the retentate, a toxic waste stream.

Keywords: membrane processes; rainwater; stormwater; reuse of water

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Comparative bibliometric analysis of research on renewable energy and industrial assets in diverse European countries

Renewable energy sources, including wind, solar, hydro, and geothermal, are assuming an increasingly pivotal role within the global energy landscape. They offer a sustainable alternative to fossil fuels, mitigating greenhouse gas emissions and making a significant contribution to the battle against climate change. The proliferation and adoption of renewable energy technologies have experienced rapid growth on a global scale, driven by governmental policies, technological advancements, and decreasing costs. Despite their numerous advantages, renewable energy sources face challenges such as intermittent energy supply, storage solutions, and integration into existing power grids. Nevertheless, with sustained investment and innovation, renewable energy sources have the potential to emerge as the predominant energy source of the future. This article conducts a bibliometric analysis of research on renewable energy sources in Poland and Germany. The analysis is based on publications catalogued in the Web of Science database, spanning the years from 1990 to 2023. The investigation delves into research topics related to renewable energy sources and examines the most frequently cited publications written by authors from these two countries. The bibliometric analysis illustrates the growing interest in renewable energy sources research within Poland and Germany. However, there remains a need for further research in specific areas, including energy storage, smart grid technologies, and the use of renewable energy in transportation. The findings from this study can serve as a valuable source of information for policymakers, researchers, and other stakeholders interested in promoting the advancement and utilisation of renewable energy sources.

Keywords: bibliometric analysis; citespace; renewable energy research; sustainable energy policies

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Analysis of the effect of the presence of microplastics on the toxicity of ionic liquids under aqueous conditions

Microplastics are one of the main types of pollutants in the environment at present. While they are in soil or water, they undergo aging processes under the influence of various physical and chemical factors that change their surface and properties. They are not inert matter in the environment and can interact with xenobiotics. So far, few articles have been published on the behavior of selected xenobiotics, such as herbicides and herbicidal ionic liquids, in the presence of microplastics. The question that needs to be asked is whether there is an interaction between microplastics and herbicides, and does this affect the toxicity of herbicides?

This study was conducted to evaluate the effect of the presence of microplastics as a sorbent on the accumulation of model herbicides and herbicide ionic liquids under aqueous conditions was studied. In the next step, toxicity tests of the analysed compounds were carried out against the model bacterial strain Pseudomonas putida KT2440.

The conducted tests confirmed the ability of the tested microplastics to adsorb the tested compounds. The amount of adsorbed compounds differed significantly - hydrophobic cations were retained on the microplastic surface, while herbicide anions were not. Toxicity tests of the tested substances showed toxic effects on the growth of the strain, and only the hydrophobic cation was responsible for toxicity. In conclusion, the presence of microplastics in the aqueous environment can be a direct cause of increased sorption by cationic surfactants. This occurrence may result in their aggregation and reduced toxicity to microorganisms.

Keywords: microplastics; ionic liquids; toxicity; adsorption; pseudomonas putida

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Adsorption of cosmetic ingredients in brackish and salt water

Anthropogenic pollutants entering the environment along with treated wastewater undergo physical and chemical changes and may also biodegrade. They pose a threat to the environment because they may have a negative impact on aquatic organisms. There is no complete information in the literature on the impact of these new micropollutants and their metabolites that have accumulated in tissues on aquatic organisms. However, it can be assumed that both they and their metabolites have an impact on living organisms, hence it is important to know the behavior of these pollutants in the environment.

The aim of the research was to assess the sorption of three groups of pollutants from commonly used cosmetic products, such as: preservatives (butylated hydrosyanisole - BHA, butylated hydroxytoluene - BHT), UV filters (benzenophenone - BZ3, ethylhexyl methoxycinnamate - OMC) and siloxanes (octamethylcyclotetrasiloxane - D4 and as reference compound due to its low harmfulness - decamethylcyclopentasiloxane - D5). Washed sea sand taken from the Baltic Sea coast was used as a sorbent. The process was carried out at a constant temperature by mixing distilled water with the addition of salt and the tested impurities with sand. Samples for analysis were collected on the first day (0) and after 1d, 2d, 3d and 6d. Liquid chromatography equipped with a DAD detector was used to analyze impurities. For all tested waters, BHT was sorbed to the greatest extent, with removal ranging from 74 to 92%. At the same time, this compound was desorbed more slowly in distilled water than BHA.

Keywords: sorption; brackish water; preservatives; UV filters; siloxanes

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Microplastics in the cosmetics industry

Microplastic is a common contaminant detected by researchers in soil, water, everyday products, food or human tissues. Its harmful effects on human and animal health and life have contributed to regulatory changes, including the use of microplastic in cosmetic products. The change is introduced by Commission Regulation (EU) 2023/2055 of September 25, 2023, amending Annex XVII to REACH with regard to microplastic synthetic polymers. The amendments are expected to help reduce microplastics emissions by 30%, according to the Zero Polution Action Plan.

The purpose of this study is to analyse the occurrence of microplastics in the cosmetics industry and alternative raw materials for replacing microplastics in cosmetic products.

The cosmetics industry uses microplastics as granules or binders in scrubs, toothpastes, shower gels, makeup products, etc. For the cosmetics industry, the new regulations mean a ban on the use of microplastic synthetic polymers, and thus ingredient substitution, which will be very difficult to do in some cases. The first to be withdrawn from sale were glitter and scrubs, the sale of which was banned on October 16, 2023. Glitter, treated as a microplastic, has been replaced on the market by biodegradable glitter produced from cellulose. There are currently transition periods for specific product groups, so the cosmetics industry has time to change ingredients to more environmentally friendly ones.

Keywords: microplastic; cosmetics industry; glitter

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Towards sustainable air cleaning: exploring the potential of biobased air filtration

Air filtration plays a crucial role in maintaining both indoor and outdoor air quality while minimising health risks from airborne contaminants. Recognising the environmental impact of petroleum-derived polymers, there is an increasing focus on sustainable alternatives, particularly biobased polymers derived from renewable resources and biomass, aiming to decrease dependence on fossil fuels and reduce material waste.

To create fibrous filtering structures, the following biobased polymers were utilized: poly(butylene succinate) from NaturePlast, polyamide 1010 from EMS-CHEMIE, and polylactic acid from TotalEnergies Corbion. Polymer nonwoven fibre mats were produced by a solution and melt electrospinning techniques. Fibre morphology was characterized by scanning electron microscope (SEM) and ImageJ software. The filtration efficiency of the fibrous mats was determined using a filter testing setup developed by Air quality research group at KTU. An electrostatic low-pressure impactor (ELPI+, Dekati, FI) was used to measure aerosol particles.

We successfully fabricated biobased nano and microfibrous composite mats using electrospinning technique, resulting in diverse morphologies of fibres. These mats demonstrated significant filtration efficiency, ranging from 60% to 90% against NaCl and DEHS aerosol particles, which corresponds to ISO ePM$_1$ 80% filter class. The unique morphology of nano and micro size fibres has reduced the pressure drop, leading to energy savings and overall reduced operational costs. These findings demonstrate the successful application of biobased polymers and their contribution towards a more sustainable filtration process.

Keywords: biobased; electrospinning; nanofibrous; filtration efficiency

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Changes in the microbial community during the operation of biologically active carbon filters used for drinking water treatment

Filtration through biologically active carbon (BAC) filters is an effective method of purifying water intended for human consumption. This process enables efficient removal of dissolved organic matter (DOM) and many water contaminants such as various xenobiotics and toxins, which is crucial for the production of safe drinking water. The main aim of the study was to describe the changes of microbial communities in BAC filters. The tests were performed on filters operating on a pilot scale. The filters differed in the composition of the supplied water: Filter 1 was fed only with tap water, and Filter 2 with tap water with addition of biohumus solution to enrich the water with microorganisms and DOM. Samples were collected in the initial stage of biofilm development and after about one year of filter operation. Analyses included physical and chemical parameters, the total number of microorganisms in 22°C, and the composition and relative abundance of microbiome using 16S rRNA metagenomic sequencing. The microbiome of filters differed significantly in the two studied period of filters' operation. In the initial stage the main group was Spongiibacteraceae from Gammaproteobacteria while in the steady stage of biofilm Xanthobacteraceae, Rhodospirillales and Rhizobiales from Alphaproteobacteria. Despite differences in the composition of inflowing water, the microbial communities in both filters were similar and the differences included taxa with low relative abundance. It was noted that during both stage of filter operation the microbial community included taxa responsible for the biodegradation of various organic compounds.

Keywords: biologically active carbon filters; drinking water treatment; microbiome; 16s rRNA analysis; biodegradation

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Media consumption rates in indoor swimming pools - analysis of design assumptions in the context of green deal implementation

The costs of maintaining an indoor public swimming pool in Poland usually significantly exceed the income from ticket sales. Almost 70% of operating expenses result from the costs of heat and electricity, as well as the demand for water and sewage disposal. Preliminary analysis of the installations in selected swimming pool facilities showed that the installations were oversized already at the design stage, what resulted in an unnecessary increase in both investment and operating costs, as well as a reduction in the quality of swimming pool water and bathing comfort. The thematic research included an analysis of contemporary design assumptions, standards, regulations and guidelines used in the design of sanitary and heating installations in swimming pool facilities. An analysis of the new design solutions already implemented, operational problems, irregularities in the design and implementation assumptions in the described scope were carried out in this work. It has been shown that the available national literature lacks up-to-date and comprehensive research on this topic. There are also no current national standards and guidelines for the design of swimming pool installations in Poland. Designers of swimming pool installations most often use the guidelines of the German standard DIN 19643, the application of which in Poland is limited due to applicable construction law regulations. A review of research published so far in the field of swimming pool technologies and installations has shown differences in the actual consumption of utilities in relation to the currently accepted assumptions. This is mainly due to the use of outdated indicators and the lack of rational use of the media. The implementation of new design guidelines and principles of operation of swimming pool devices and installations will allow for the improvement of water, sewage, heat and energy management in swimming pool facilities.

Keywords: swimming pools; media consumption; green deal strategies; sustainability

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Delamination techniques for multilayer packaging recycling: advances and challenges

Multilayer packaging, with its composite structure of various materials, has become a mainstay in the packaging industry, offering exceptional product protection and extended shelf life. However, its complexity presents unique challenges when it comes to recycling. This poster investigates the state of delamination techniques in the context of multilayer packaging recycling, with an emphasis on advances, challenges, and environmental considerations.

The review highlights notable advancements in the field, such as the use of specialized equipment, novel chemical agents, and innovative process designs to enhance the efficiency of delamination. Delving into these advancements, we assess their potential impact on recycling practices, addressing their benefits in terms of reducing waste and minimising the environmental footprint.

Moreover, the poster elucidates the persistent challenges facing delamination techniques, including cost-effectiveness, scalability, and environmental implications. Effective recycling solutions must align with sustainability goals, ensuring a holistic approach to materials recovery.

As the global drive toward sustainable packaging intensifies, this research aims to foster a comprehensive understanding of the complexities and opportunities within the realm of multilayer packaging recycling. By examining the advancements and challenges in delamination techniques, it seeks to contribute to the ongoing dialogue surrounding sustainable packaging practices and their pivotal role in the broader recycling ecosystem. This poster underscores the urgency of refining these techniques for optimal recyclability while fostering a more sustainable, circular economy in the packaging industry.

Keywords: delamination techniques; multilayer packaging; recycling advancements; sustainability challenges; environmental implications

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Waste-free method to develop biocompatible hydrogels for regenerative medicine applications

The increasing demand for sustainable and environmentally friendly methods in regenerative medicine has prompted the development of waste-free approaches to create biocompatible hydrogels. By using renewable resources and environmentally friendly curing agents, the amount of waste generated during hydrogel synthesis is minimized, helping to reduce environmental impact. The introduction of "green chemistry" principles ensures that the entire life cycle of a hydrogel, from raw material extraction to degradation, is subject to environmentally responsible practices. Hydrogels, known for their versatility, play a key role in tissue engineering and regenerative medicine applications. The aim of the present research is to develop a waste-free technology for manufacturing biomaterials. In this study, composite biomaterials were created based on biodegradable polymers and a polysaccharide, which was pullulan. A crosslinking agent and a photoinitiator were added to the system. The obtained system was subjected to a photocrosslinking process under a UV lamp for a period of 4 minutes. The obtained hydrogel biomaterials were subjected to physicochemical analysis. A 14-day incubation in fluids simulating the body's internal environment and pH-metric tests were carried out. The tests demonstrated that the pH in fluids simulating the internal environment changes slightly. The obtained polymer composites may represent next-generation systems for controlled drug release in regenerative medicine. The proposed solution represents a waste-free method where no toxic by-products are formed, which is very important in terms of application in regenerative medicine in particular and fits perfectly into the principles of "green chemistry."

Keywords: biomaterials; biopolymers; biosaccharides; photocrosslinking

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Cultured meat vs. conventional meat – comparison of the environmental impact of meat production

Cultured meat (also known as, e.g., clean meat, cell-based meat, cultivated meat, in-vitro meat), is meat obtained via animal cell multiplication in bioreactors. The main objectives of this study were to evaluate the sustainability of clean meat production, identify what variables influencing its negative impact on the environment can be manipulated in the process of clean meat production, and to compare the environmental impact to conventional meat production. The aforementioned evaluations, assessments and comparisons were performed by reviewing the contemporary literature on the subject. The most important conclusions concern the high energy consumption in the production of clean meat, with the source of the energy (depending on whether renewable on non-renewable) having a major impact on sustainability of clean meat. This conclusion reinforces the position, that meat, especially red meat is resource intensive in production and scores high on the GWP (Global Warming Potential), regardless whether being produced conventionally or in vitro. Second, there are significant differences between the environmental impact depending on the type of meat farmed, where certain meats farmed via conventional methods, especially poultry and fish, score lower on the GWP than red meat and cultured meat. Lastly, the variable in the production of cultured meat that makes the biggest difference in the environmental impact is the type of cell growth medium used.

Keywords: cultured meat; sustainable food sources; meat production; global warming potential; environmental impact

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Emission of micro-contaminants from gasoline light-duty vehicles

In addressing emissions from vehicles, the European Union's rigorous Euro Emission Standards effectively regulate gaseous pollutants such as CO, CO2, HC, NOx, as well as particulate matter (PM) and particle number (PN). However, substantial quantities of additional pollutants emanate from the engine aftertreatment system, brakes, and tires. These compounds, including polycyclic aromatic hydrocarbons (PAHs) and their derivatives, despite their documented adverse effects on health and the environment, currently lack regulatory oversight.

The poster presents statistical insights into average mileage, PAHs emissions, and the total number of vehicles across the European Union. The study specifically delves into the examination of five PAHs from particulate matter emitted by direct injection gasoline vehicles conforming to the current Euro 6d Emission Standard. Additionally, the Toxic Equivalency Quotient (TEQ) of the PAHs is showcased, providing a comparative measure in terms of benzo[a]pyrene (B[a]P) equivalence.

Given the ambitious goals of the European Union's Fit For 55 program to phase out internal combustion engine vehicles by 2035, the persistence of conventional fuel-powered vehicles on the roads after that date is expected. This underscores the significance of understanding and mitigating the impact of micro-contaminants such as PAHs, especially considering harmful nature of non-regulated compounds. In light of these challenges, it becomes imperative to foster a collaborative approach to address and minimize the environmental impact of vehicular emissions.

Keywords: micro-contaminants; direct injection spark ignition; emission; Polycyclic Aromatic Hydrocarbons (PAHs)

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Guarantee of origin mechanism as an element of the green energy transformation in Poland

A transition from generating electricity from conventional sources to generating it from renewable sources is one of the elements of the drive towards a circular economy. Electricity is a specific product and regardless of where and how it is produced, it takes the same form.

A novel aspect of the research is the examination of correlations and relationships between the guarantees of origin.

This study as the research objective adopted the analysis of the market for the guarantees of origin in the volatile environment of the electricity price shock at the turn of the 2021-2022. An analysis of the demand for the guarantees of origin in the period from January 01, 2020 to June 30, 2022 and an analysis of the correlation between the price of electricity and the guarantees of origin were performed. The secondary data analysis method was applied, Pearson's correlation coefficient was utilised and a linear regression function was derived.

The authors of the study hypothesised that trading volume of the guarantees of origin increased during the period under study, and that there was a positive correlation between the price of energy and the guarantees of origin.

A key finding of the study revealed a steady increase in the purchase of the guarantees of origin despite the rise in volume prices. The purchase of the guarantees of origin is not a top-down requirement, but rather the bottom-up one, which is indicative of growing social expectations towards enterprises to consume energy from renewable sources.

Keywords: renewable energy sources; energy production; energetics; energy trading

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Selecting the effective sorbent for removing PAHs from water

Polycyclic aromatic hydrocarbons (PAHs) are very important pollutants due to their carcinogenicity, mutagenic and toxic properties, and persistent nature. Particularly important is the content of PAHs in water. Water intended for human consumption should meet certain requirements. The documents regulating the permissible concentration of PAHs in water intended for human consumption are Directive of the European Parliament and of the Council (EU) 2020/2184, 2020. In Poland, the applicable legal act is and the Regulation of the Minister of Health of December 7 (2017) on the quality of water intended for human consumption. A number of techniques are used to remove PAHs from the environment, including selective adsorption on activated carbon and, more recently, the use of a sorption process on biocarbon is being considered. An evaluation of the sorptive capacity of activated carbon and biocarbon to remove PAHs from the aquatic environment was compared. To evaluate the efficiency of PAH removal, water was modified with PAH MIX A standard solution to obtain a total concentration of normalized PAHs higher than that allowed in water intended for human consumption. The sorption process was carried out for CWZ-22 CWZ-30 powered activated carbon and biocarbon obtained from chicken manure. The application of CWZ-22 and CWZ-30 reduced the concentrations of benzo(a)pyrene by 49.5% and 66.1%, respectively, while the total concentration of four PAHs decreased by 69.7% and 67.6%. Better results were obtained for chicken manure biocarbon where a reduction of 80.2% in the concentration of four PAHs was achieved.

Keywords: powered activated carbon; polycyclic aromatic hydrocarbons; sorption; removal efficiency

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Carbon footprint on food labels - fashion or necessity?

Studies on the effects of climate change indicate that high levels of greenhouse gas (GHG) emissions are the main threat to economic development and the state of the world's environment. More and more consumers are concerned about the impact of food not only on their health, but also on planet-saving behaviour. In response to the emerging threats of climate change, climate labels have been developed to indicate the carbon footprint of products. The environmental impact is examined throughout the life cycle of the product. Factors relating to air, water, ocean and soil pollution are taken into account, as well as the impact on the biosphere.

The aim of this paper is to present the current state of knowledge regarding information to consumers on greenhouse gas emissions associated with product manufacture on food labels. A literature-based analysis of the state of knowledge indicates that it is necessary to provide consumers with clear information on the environmental footprint so that they can easily and quickly compare it for several products. This approach is enabled by the Eco-Score environmental assessment. The Eco-Score food label is designed on an A to E rating model, which summarises 15 environmental impacts. The Eco-Score is represented by a leaf-shaped logo in a coloured font with letters ranging from A (very low impact) to E (very high impact). The labels indicate the environmental impact of the product, i.e. the greenhouse gas emissions consumed in the creation, transport, use and end-of-life of the product, measured in grams or kilograms of carbon.

Keywords: greenhouse gas emissions; food carbon footprint; eco-score; consumer

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Polystyrene as a potential pollutant of sorbing herbicides in aqueous systems

It is evident that the increasing, global production of synthetic polymers has created widely-spreading environmental pollution in the form of microplastics, such as polystyrene. These substances can behave as potential sorbents, creating additional, emerging pollutants in natural environments like ground waters, lakes and oceans. Several studies have indicated, thus far, that microplastics can affect sorption processes of various xenobiotics, like herbicidal ionic liquids, in aquatic systems. Notably, microplastics are capable of increasing the sorption processes thereof, affecting the mobilities of the respective anion and cation. Therefore, this study examined the sorption effects of herbicidal ionic liquids on 1-10% (w/w) micro-polystyrene (MPS) in an aqueous system. The selected ionic liquid was based on the herbicidal 2,4-D anion, modified by two cations (choline and choline with a twelve-carbon chain). The results proved that the sorption of the choline cations increased between 16-18% with an increasing w/w PS amount. Noticeably, there was no sorption observed for the 2,4-D anion. This indicates that the ionic liquid exists in the aqueous environment as two separate ions. Notably, PS increases the retention of the cations in the system which can act as harmful contaminants, impacting the biological processes adversely. Clearly, this is a serious issue to take note of as one can see that microplastics enhance the conversion of both previously unharmful and harmful substances into emerging contaminants in the natural environment.

Keywords: sorption; emerging contaminants; microplastics; xenobiotics

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Breaking the barrier: exploring acidic solutions for delaminating multilayer aluminum packaging in the food industry

Multilayer aluminum-based packaging materials play a pivotal role in the food industry, preserving product integrity and enhancing shelf life. Yet, their intricate layer bonding poses a substantial obstacle to effective recycling. This study systematically investigates the potential of acidic delamination solutions, focusing on nitric acid, lactic acid, and a lactic acid-choline chloride mixture, for the separation of multilayer aluminum packaging.

Our methodology comprised a series of laboratory-scale experiments conducted in a reactor equipped with essential components: an ultrasonic bath, flask, and overhead stirrer. The ultrasonic bath, operating through mechanical vibrations, initiated the separation process, while the overhead stirrer ensured consistent and uniform agitation of packaging materials within the flask.

The findings reveal the delamination capabilities of the three solutions. Nitric acid, known for its robust oxidising properties, emerged as a potent delamination agent, effectively disrupting inter-layer bonds. Lactic acid, chosen for its milder attributes, showed promise in facilitating layer separation, presenting a more environmentally benign alternative. Notably, the lactic acid-choline chloride mixture, representing an eco-friendly formulation, demonstrated significant potential by balancing efficacy with environmental considerations.

This study underscores the substantive potential of acidic delamination solutions for multilayer aluminum packaging. Effective delamination serves as a pivotal step in rendering these materials recyclable, significantly reducing waste generation and environmental impact. As the global drive towards sustainability intensifies, this research contributes to the broader endeavor to reduce waste, lessen environmental burdens, and promote responsible resource management in the food packaging sector.

Keywords: delamination solutions; multilayer aluminum packaging; acidic agents; recycling methods; sustainability in packaging

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Environmentally friendly and waste-free method for obtaining tissue replacement materials

Responsible production, consumption, reuse or recovery are the pillars of the zero waste concept, which can realistically improve the environment and translate into human life. The rapid development of society, and thus the technology for obtaining materials for various purposes (packaging industry, transport, construction or medicine) has contributed to the generation of a large number of by-products, which either become waste and end up in landfills, or require the investment of additional costs by industry for their safe disposal. In line with the idea of "Zero Waste," the emphasis should be placed on resource efficiency and waste avoidance from the beginning of process planning. This will not only allow rational management of raw materials, but also contribute to more economical disposal of costs.

The aim of the presented research was to develop a waste-free and environmentally safe technology for obtaining materials by photocrosslinking for medical use. The irradiation time and UV dose were selected, as well as appropriate ratios of photoinitiator and polymeric crosslinking agent based on polyethylene glycol diacrylate. As a result, a flexible polymeric material for tissue replacement was obtained within 4 minutes. It was based on biopolymers like hyaluronic acid, collagen and inulin. The final material assumed the shape of the vessel it was in, so 100% of the substrates were used. The method is therefore economic, but also eco-friendly. It does not require the use of aggressive reagents or toxic solvents, and is based on biopolymers of natural origin, which are safe for the environment.

Keywords: photocrosslinking; waste-free technology; polymers; tissues

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Solar-driven degradation of ciprofloxacin – photocatalysts comparison and effect of co-existing anions

The presence of antibiotics in aquatic environments raises concerns about antimicrobial resistance development, environmental disruption, and potential health impacts on organisms. Conventional wastewater treatment plants (WWTPs) stand as a primary contributor to antibiotics in the environment, showcasing inefficient removal of these compounds. Photocatalysis presents a promising solution, as an additional purification step attributed to its higher efficiency in the degradation of these micropollutants within complex aquatic matrices.

The aim of the study was to assess the removal efficiency of ciprofloxacin (CIP) by solar-driven photocatalysis using TiO_2 and ZnO. Tests were also conducted in the presence of co-existing anions, namely SO_4^{2-} and Cl^-, which are abundantly present in water matrices, and can act as a radical scavenger. The experiments were carried out in distilled water (DW) and tap water (TW) spiked with 2 mg L^{-1} of CIP, photocatalyst concentrations of 20 mg L^{-1} each, and an anion concentration of 250 mg L^{-1}. Control tests, including photolysis and sorption test, were performed in parallel with the photocatalytic experiments. Studies were carried out in a solar radiation simulator.

During all experiments, the concentrations of CIP were reduced to >90%, and the most effective process turned out to be photocatalysis in DW using TiO_2, because such removal was observed after only 5 minutes. The efficiency of photocatalytic degradation of CIP depends on the type of photocatalyst, matrix complexity, and the presence of anions. Solar-driven photocatalysis is a promising method to treat aquatic matrices and it can limit the formation of by-products during the process.

Keywords: anions; ciprofloxacin; photocatalysis; titanium dioxide; zinc oxide

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Increase the ecological safety of the soil biogrouting

A new area of biotechnology - the use of microorganisms for the needs of construction has been successfully developing in the world over the past 15 years. The production of biomement and soil enhancers based on the use of urease-producing bacteria, which in the presence of urea and calcium ions in an alkaline medium form insoluble calcite crystal, occupies a special place among new building materials. The advantage of biomement over traditional cement is its low viscosity (30–300 times less than the viscosity of a cement suspension) that ensures its ability to penetrate deeply into the pores and cracks of soil, concrete or stone. The disadvantages of the biocementation process are the potential biohazard from the used urease-producing bacteria and the unpredictable effect of introducing a significant amount of live bacterial biomass into the environment in the case of soil biogrouting. The use of plant-derived urease instead of bacterial urease is the way for a wide and environmentally friendly application of this biotechnology for soil biogrouting.

Screening of seeds of agricultural crops grown in Ukraine showed that soybean seeds can be used as a source of urease for biocementation in the form of a crude aqueous extract from the crushed mass of the seeds themselves or germinated within 24-48 hours. The use of a crude extract from soybean seeds showed its effectiveness for the precipitation of calcium carbonate from a mixture of solutions of calcium chloride and urea, and its use in the biocementation of sand made it possible to reduce its water permeability by 6000 times and obtain values corresponding to the seepage rates of sand biocemented with traditionally used urease-producing bacteria.

The advantages of this method of biocementation are evident: (a) there is no need to grow a microbial producer of urease, that is, the technology is greatly simplified; (b) the crude extract can be prepared just prior to its use; (c) the cost of the biocementation process is significantly reduced, since there is no need for a nutrient medium for bacteria cultivation, electricity consumption for aeration in the growing process, and the use of highly qualified personnel to obtain microbial biomass with urease activity; (d) one of the important problems of biocementation is completely solved – cells of the microbial urease producer do not enter the environment, and an aqueous solution of homogenized plant biomass does not need additional determinations of its biosafety. This biocementation method can be used as an environmentally friendly and sustainable method for solving numerous geotechnical problems, such as soil stabilisation, elimination of the consequences of soil liquefaction during earthquakes, soil protection from erosion, the atmosphere from dust, and chemical pollutants.

Screening of seeds of agricultural crops grown in Ukraine showed that soybeans can be used as a source of urease for biocementation in the form of a crude aqueous extract from the seed mass itself or germinated within 24–48 hours.

The use of a crude soybean seed extract has been shown to be effective in precipitating calcium carbonate from a mixture of calcium chloride and urea solutions.

The use of a crude soybean extract in the biocementation of sand made it possible to reduce its water permeability and obtain values corresponding to the seepage rates of sand biocemented with traditionally used urease-producing bacteria.

Keywords: soil biogrounting; biomement; biocementation

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Methods for efficient and economical production of hydrogel materials

The main objective of the study is to learn about and familiarise oneself with the various methods of obtaining hydrogels with a particular focus on reaction efficiency and economy in production. Hydrogels, as important polymeric materials, are gaining in popularity due to their applications in the fields of medicine, biotechnology or engineering. Consequently, their demand is increasing, and it is important to develop methods that are efficient and economical in the production of the aforementioned materials.

A very important step in obtaining hydrogel materials is their cross-linking, which also affects the properties of hydrogels. Another very important factor in efficiently and economically obtaining hydrogels is the substances used in the process. Hydrogels are colloidal systems in which the dispersed phase is water, and the dispersing phase is mainly natural or artificial polymers or their modifications. This is another important factor that should be taken into account when producing hydrogels, as the properties of the resulting material depend on this.

In the context of raw material savings, biopolymers are used in the production of hydrogels, which not only reduces the environmental impact, but also reduces production costs. It is worth noting that the polymer used to produce hydrogels can be, for example, albumin, which is a very readily available protein with valuable properties such as biodegradability and biocompatibility. It is difficult to find the ideal method for obtaining hydrogels. It all depends on the desired properties and the materials used.

Keywords: hydrogels; chemistry; polymers; biotechnology; receiving materials

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The threat of heavy metal release into water as a result of its contact with pipes made of plastic materials

In accordance with applicable regulations on the quality of water intended for human consumption, the concentration of heavy metals in drinking water is limited due to its impact on human health. It was assumed that depending on the type of pipe material and the quality of the transported water, heavy metals may be released into the water during its transport to the consumer. To verify this thesis, research was carried out for selected materials often used in water distribution, i.e. polyvinyl chloride (PVC) and polyethylene (PE).

The new pilot-scale installation has been in operation since April 2023 at the Institute of Environmental Engineering and Building Installations of the Poznan University of Technology. It consisted of two independent water distribution installations made of PVC and PE. The research was conducted for half a year, for 3 months under static conditions and for 3 months under dynamic conditions. Water samples were collected from inflow and outflow of each analysed installations. Physicochemical analyses of water quality were performed, including alkalinity, pH, redox potential, oxygen, chlorine and heavy metals concentrations (zinc, cadmium, copper, nickel, and lead). All determinations were made according to the standards methods for water and wastewater analysis.

The research results confirmed that the release of heavy metals into water occurs as a result of its contact with PVC and PE pipes and that the physical and chemical quality of the transported water is one of the factors influencing this process.

Keywords: drinking water; heavy metals; plastic materials; PVC; PE

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Utilisation of Moroccan microalgae Arthrospira platensis as a liquid nutritional supplement

With changing dietary preferences in modern society and an increasing recognition of its superior nutritional attributes, including amino acid content and digestibility, there is a growing shift in industrial and research efforts toward the development of cost-effective and stable liquid nutritional supplement derived from microalgal biomass. This supplement has the potential to emerge as a valuable nutritional resource, especially for populations facing famine or malnutrition, whether due to climate change or other contributing factors.

The current work evaluates the possibility to develop liquid dietary supplements from a Moroccan microalgae; Arthrospira platensis. Different hydrolysis methods were used (ultrasound-assisted hydrolysis UAH, acid hydrolysis AH, thermal hydrolysis TH and enzymatic hydrolysis EH) and their efficiency evaluated thought the hydrolysates composition analysis (proteins, carbohydrates, lipids and pigments mainly phycocyanin). The antioxidant activity was also evaluated by DPPH method.

Results show that, EH treatment gave the highest protein content 78% for spirulina independently of used dose. Pigments were also increased with this treatment: 4.5mg/ml of phycocyanin. AH increased carbohydrates liberation 17% without dose dependent effect. Nevertheless, proteins and pigments were fully degraded under these conditions. UAH treatment particularly increased lipids 21% and carbohydrates 25% in hydrolysates of spirulina. Neither proteins nor pigments contents varied with this treatment. The highest antioxidant activity was observed with EH (scavenging activity> 95 %), probably due to the elevated pigments content.

To conclude, EH is recommended for liquid form production due to the high nutritional quality and antioxidant activity of the hydrolysates.

Keywords: Moroccan microalgae; arthrospira platensis; hydrolysis methods; liquid nutritional supplement

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Reduced environmental pH as the main cause of acid corrosion of concrete structures

The subject of this research was to discuss a method for preliminary evaluation of the durability of concrete structures exposed to acetic acid. The types and degree of damage caused were analyzed, and the usefulness of surface morphology studies and SEM imaging in this assessment was demonstrated. The experiment focused on acetic acid exposure of cubic samples of ordinary concrete with different water-cement ratios.

The samples were immersed in acetic acid for 290 days. The 10% acid concentration used was adopted according to the so-called accelerated method. This allows faster evaluation of the effects of acid corrosion of concrete under laboratory conditions. Subsequently, the compressive strength of the specimens was determined, and their surface morphology was evaluated by measuring roughness parameters.

It was shown that the compressive strength of the samples stored in acetic acid was 36-50% lower than that of the reference samples. The smallest decrease in strength occurred for samples with a W/C ratio below 0.43. As the value of the W/C ratio increased above 0.5, there was a decrease in the resistance of the concrete to acetic acid. SEM microstructural analysis also confirmed the destruction mechanisms taking place caused by the reaction of acetic acid with portlandite and the C-S-H phase, as well as the leaching of calcium ions.

Lowering the W/C ratio of concretes used for agricultural tanks can be a simple and effective way to increase their durability and extend their service life, which will bring tangible economic benefits to the farm and environmental benefits to the environment.

Keywords: concrete; acid corrosion; environmental protection; microscopic analysis

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Adsorption of micropollutants of pharmaceutical origin on microplastic particles

Microplastics are one of the biggest pollutants of whose 20th century, the nature is not fully understood. It is known to occur in every ecosystem and is even a component of humans. It is also known that humanity will not be able to eliminate it for hundreds of years, and the wide use of plastics means that they will not be withdrawn from use. An additional disturbing factor is the possibility of sorbing chemical compounds on its surface, which can be called cotransport of pollutants.

In the experiment, it was decided to contact a pharmaceutical belonging to NSAIDs (non-steroidal anti-inflammatory drugs) with microplastic particles. A relatively new drug was selected - celocoxib. Two types of plastics were used and transformed into microplastics: polyurethane foam and a tire. During this process, samples were taken to analyse the change in the concentration of the pharmaceutical, and an additional blind test was conducted. The loss of pharmaceutical concentration was analysed using HPLC - high-performance liquid chromatography combined with UV-Vis detector. When tyre samples were contacted with pharmaceuticals for 180 minutes, the concentration was below LOD (limit of detection). When celecoxib was contacted with polyurethane foam microplastics, a concentration loss of over 33% was recorded. An analysis of a sample that had not been contacted with microplastics was also performed. In this case, the drug concentration did not change. Research has confirmed that microplastics have the ability to adsorb pharmaceuticals, which indicates cotransport in the environment. Depending on the material from which the microplastic is made, these possibilities vary.

Keywords: microplastic; adsorption; pharmaceutics; emission; transport to environmental

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Multiparametric study of a filter bed from a swimming pool water treatment system

The main purpose of this paper was to present the results of a multiparametric study of a filter bed (multilayer bed: gravel-sand-anthracite), used in a circulating pool water treatment system for the past 20 years. The influence of the age of the bed on the efficiency of the filtration process was studied, as well as the relationship between the various parameters of the filter bed. The possibility of reusing the waste obtained after replacing the filter bed was evaluated according to the principles of closed-loop economy. The scope of the study included basic physicochemical analysis (total organic carbon, nitrates, and phosphates) of filter bed extracts, microbiological analysis (Escherichia coli, Pseudomonas aeruginosa, most probable number (MPN) of mesophiles and psychrophiles and coli forms) of individual bed layers, advanced examination including chromatographic analysis of micropollutants, ecotoxicity analysis of filter bed extract, and analysis of bed structure using scanning microscopy. Multiparametric analysis of extracts from the bed used showed the adsorption of a wide variety of contaminants and high concentrations of both of a chemical and microbiological nature, on the surface of all materials and filter layers. Moreover, the analysed samples showed inhomogeneous adsorption of contaminants in both vertical and horizontal sections of the bed, as well as high toxicity according to the commonly accepted simplified toxicity classification system. Such a wide range of studies allowed us to obtain a complementary view of the quality of the filter bed, its impact on the efficiency of the filtration process, and the possibility of reusing the waste obtained after replacing the filter bed.

Keywords: pool water treatment; filter bed; chemical and microbiological contaminants; micropollutants; toxicity classification

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Ultrasonic support for the removal of selected micropollutants from sewage sludge

Municipal wastewater treatment (WWTP) becomes a source of anthropogenic pollution that enter the environment through treated wastewater and processed sewage sludge. Based on the uptake mechanism of pharmaceuticals, they are excreted as a combination of metabolites, primary substances, and random byproducts. Because pharmaceuticals are usually only partially metabolized, they end up in WWTP, where large amounts of these substances are insufficiently removed by traditional technological systems of WWTP and can therefore be released into the environment. Ordinary plastic, on the other hands, characterized by negligible and slow biodegradability, threatens the environment due to mass production and careless and excessive use by society, leading to littering and contamination.

Ultrasonic disintegration of sewage sludge can influence the appearance of pharmaceutical contaminants and microplastic (MP) in the liquid after the process, as well as their degradation. The aim of the research was to determine the possibility of degradation of selected pharmaceuticals and decomposition of MP using an ultrasonic field (20 kHz) as a disintegrating factor. Based on the research performed, i.e. quantitative analysis, the distribution of the studied groups of micropollutants as a result of the process was found. Supporting the degradation process of pharmaceuticals and the decomposition of MP present in sewage sludge subjected to sonication was associated with the active effect of the ultrasonic field, i.e. a local increase in pressure and temperature, and especially the phenomenon of ultrasonic cavitation. This method is a promising process solution supporting conventional methods of sludge disposal and post-treatment of wastewater used in WWTP.

Keywords: sewage sludge; pharmaceuticals; microplastics; disintegration; sonification

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Technology of thermal valorisation of tanned leather wastes for sorption and energetic valuable materials

In Poland, 40 mln shoes are produced each year. End of life shoe become a waste that is difficult to manage because of multimaterial nature and complicated construction. Other problem in management of end of life shoes is that there is no methods of selective collection of shoes depends on materials that there are made off. Therefore, there is a need to improve end of life shoes management by new recycling methods, which are compatible with circular economy pattern. Based on scientific reports and experience in solid waste management high tempetature neutralisation process (pyrolysis) was purpose for leather shoe elements recycling.

The aim of preliminary work was to investigate on composition of solid leather waste using X ray fluorescence spectroscopy. Samples were characterised by a high chromium content (56,25%) which is connected with tanning process used for leather production. Pyrolysis tests was driven in various temperature conditions (500°, 700°C, 900°C) using Czylok FCF-12 furnace with CO_2 as a inert gas. The result of pyrolysis was a different mass loss carbonisates (51% in 500°C, 65,5% in 700°C, 72,6% in 900°C). That shown influence of the pyrolysis temperature on structure degradation of samples. In the next step carbonisates obtained from each process will be investigate on sorption and energetic value potential

Keywords: circular economy; leather wastes; pyrolysis; sorption; shoe recycling

Acknowledgments: The work was created as part of the project " Recycling processes and dismounting of general footwear components, including electronic modules, with ways of reusing components and materials, based on a modular construction" (Acronym: ReProcess_Shoe) co-financed by the National Center for Research and Development under the Cornet Initiative (Agreement No. CORNET/33/141/ReProcessShoe/2023).

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Rainwater and stormwater quality in terms of its potential use in swimming pool installations

The background of the topic discussed in the presented research is the rapid development and widespread implementation of rainwater (RWH) and stormwater (SWH) harvesting. The numerous environmental advantages of these strategies led to a variety of uses for both rainwater and stormwater. Many examples such as toilet flushing, car washing, cooling, laundry or firefighting demonstrate the versatility of reusing these water streams in various sectors, highlighting its potential to save water resources and promote environmentally responsible practices.

The objective of this paper is to provide a critical evaluation of the data available from existing studies regarding the rainwater and stormwater quality in terms of its potential use in swimming pool installations.

The scope of this paper includes a review of current scientific research on the quality of rainwater and stormwater based on available literature data and relating them to the requirements that water in swimming pool installations should meet.

Results of the performed literature review shows that the utilisation of rainwater and stormwater in swimming pool installations is the novel and innovative subject that necessitates additional exploration and study is. The first attempts are already being made to use rainwater from roofs for the purpose of backwashing swimming pool filter beds.

It was concluded that rainwater and stormwater appear to be a cost-free and valuable water source for swimming pools, particularly in light of the current European Green Deal Strategies. However, the discussion about using it to fill public swimming pools raises certain legal ambiguities. The pool and spa industry adheres to a diverse set of standards and lack uniformity, exhibiting variations from one country to another. Thorough planning and management, as well as adherence to local regulations are crucial.

Keywords: rainwater harvesting; stormwater harvesting; swimming pool installations

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Non-toxic biosynthesis of silver nanoparticles using mutant yeast

Silver nanoparticles (AgNPs) have considerable advantages over their macro analogs due to their unique physico-chemical properties, thanks to which they are used in different fields of chemical, food and pharmaceutical industry. Traditional way of obtaining AgNPs is the chemical method, however it leads to environmental pollution as it includes the use of toxic chemicals like sodium borohydride and polyethylene glycol. Thus, it is safer to use biological methods, which apply microorganisms for silver ion recovery and nanoparticles formation. The application of yeasts as biological agents, particularly yeasts of the genus Saccharomyces, attracts increasing attention as they are safe for humans and don't need special biosafety measures. A mutant strain of yeast Saccharomyces cerevisiae was produced using ultraviolet irradiation. Yeasts were cultivated on synthetic Reader medium and afterwards cell-free aqueous extract was prepared, to which argentum nitrate was added in 0.5-3 mM concentrations. Biosynthesis of AgNPs was performed at different temperatures (30, 35, 40, 45, and 50 ℃). The synthesis of biogenic AgNPs was confirmed through the definition of absorbance spectra at wavelengths ranging from 350 to 650 nm. Pronounced absorption peak of AgNPs synthesized using the cell-free aqueous yeast extract was registered at the wavelengths ranging from 300 to 550 nm with peak at 420 nm. It was shown that the most intense biosynthesis of AgNPs occurred in the samples with the concentration of 0.5 mM $AgNO_3$ and incubation temperature of 45 ℃. The described method of biosynthesis of silver nanoparticles is a promising and environmentally friendly approach to obtaining a material with unique properties.

Keywords: biosynthesis; silver nanoparticles; yeasts; ecology

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The impact of FA and FNA on the suppression of NOB in nitritation-anammox systems for WWTPS

To successfully launch a nitritation-anammox system for wastewater treatment process, it is crucial to control the levels of free ammonium (FA) and free nitrous acid (FNA) in order to suppress the growth of nitrite-oxidising bacteria (NOB) at optimal temperatures specified for treating wastewater from anaerobic digestion. The NOB suppression also requires a combination of such factors as a low DO concentration, a rapid transition from aerobic to anoxic conditions, and tight control of temperature and/or pH. The aim of this study was to investigate the effects of FA and FNA inhibition on the suppression of NOB and to enhance ammonia-oxidising bacteria (AOB) growth in a lab-scale SBR at the temperature of 30°C for synthetic reject water treatment systems. FA of 17.2 mg FA/L at pH of 8.3 occurred the most favourable NO_2 accumulation/AUR ratio (0.49), indicating a nearly 50% decrease in nitrate accumulation and the strongest inhibitory effect on NOB activity. The major driving force behind the successful NOB washout is the inhibition of those bacteria based on the difference in the growth rate between AOB and NOB, throughout the nitritation process, whether acting alone or in combination with FA-FNA components. Moreover, the combined impact of FA-FNA enhances NOB suppression, the FA approach outperformed other methods in terms of NO_2 build-up and process effectiveness, since it maintained more significant AOB activity.

Keywords: nitrogen removal; FA; FNA; NOB suppression; nitritation; WWTP

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Strategies toward Green Deal Implementation in the context of the SCG reuse and recovery as a high value-added product in the Circular Economy Model

The paper discusses future perspectives with respect to integrating and utilising resources database for the reuse and recovery of the main coffee industry residues from environmental and economical points of view in the context of the implementation of the Circular Economy Model (CEM). As the global coffee consumption increases steadily every year, the production of Spent Coffee Grounds (SCG) has also increased rapidly worldwide, providing great potential for resource recovery and recycling. SCG are the solid residue resulting from coffee brewing, either domestically or at an industrial level in the production of soluble coffee. Therefore, this review summarises current knowledge on the output, management, characterisation, treatment and different methods for resource recovery and recycling of spent coffee grounds in an attempt to promote understanding of SCG. Moreover, there are some approaches recently reported such as extraction, co-digestion, compost, conversion into biochar or biodiesel production and reusing for construction or water treatment. However, the community of SCG researchers is relatively small and isolated without timely information interchange, so this kind of high value-added products in the context of the strategies toward Green Deal Implementation and CEM is strongly recomended.

Keywords: spent coffee grounds; circular economy; water treatment; recycling; resource recovery

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Sustainable aluminum recovery from multilayer packaging wastewater: fluidized-bed homogeneous crystallisation innovations

This research illuminates an innovative approach devised to address the pressing environmental concerns associated with multilayer flexible packaging materials and, concurrently, the recovery of aluminum from the wastewater byproducts generated in the recovery process. The investigation centers on the utilisation of fluidized-bed homogeneous crystallisation technology, specifically tailored for the efficient and sustainable extraction of aluminum - a pivotal constituent of these complex packaging materials.

The research methodology systematically integrates the distinctive attributes of fluidized-bed homogeneous crystallisation to selectively retrieve aluminum from intricate wastewater streams originating from the recovery process of multilayer flexible packaging materials. This application of innovative technology demonstrates a potent solution for the segregation of aluminum, a task marked by inherent complexities due to the heterogeneous composition characterising the materials under examination.

The findings underscore the profound efficacy of fluidized-bed homogeneous crystallisation in attaining selective aluminum crystallisation, thus enhancing the overall efficiency of the recovery process. This seminal development bears notable significance in terms of resource conservation and waste reduction, aligning closely with the imperatives of environmental sustainability.

Furthermore, the research underscores the environmental implications intrinsic to the deployment of fluidized-bed homogeneous crystallisation technology, accentuating its pivotal role in waste reduction, aluminum resource preservation, and the overarching advancement of sustainability within the multilayer packaging industry.

The pioneering application of fluidized-bed homogeneous crystallisation technology stands as a significant stride toward ecologically responsible aluminum recovery and sustainable solutions for the multifaceted multilayer packaging industry. This poster endeavors to make a substantive contribution to the ongoing discourse on responsible resource management and to stimulate the inception of progressive innovations, all in service of a greener, more sustainable future.

Keywords: fluidized-bed homogeneous crystallisation; aluminum recovery; multilayer flexible packagin; sustainable resource management; wastewater treatment

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Application of co-pyrolysis biochar for the removal and immobilisation of lead and zinc

Waste-derived biochar is gaining prominence, aligning with the Environmental Green Deal's goals for environmental protection. This study investigated the characteristics and application of commercial biochar from the co-pyrolysis of cereal straw and woodchips, emphasising its potential in removing lead (Pb) and zinc (Zn) from aqueous solutions. The biochar, obtained from Treeden Group Lublin NTP Sp. z o.o. (Poland), was produced in the NTT-1 carbonizer. Batch adsorption experiments explored single and mixed metal scenarios, varying biochar dosages (1.25-5 g d.w./L), sorption time (5 min.-24h), pH (3-8), and initial metal concentrations (25-300 mg/L). The metals adsorbed on biochar were fractionated into different fractions, allowing the determination of metal stability using the reduced distribution index (I_r).

The biochar exhibited alkaline pH (9.77) and high cation exchange capacity (51 cmol/kg). Optimal metal removal conditions were identified at a biochar dosage of 10 g d.w./L, a sorption time of 2 hours, and a pH of 5.0. The Langmuir model revealed a higher maximum adsorption capacity (in mg/g d.w.) for Pb (26.8 for single, 11.2 for mixed) compared to Zn (6.7 for single, 1.6 for mixed). As the initial metal concentration increased, stability remained relatively constant for single metals but increased for mixed metals. Pb exhibited greater stability (I_r = 0.73) than Zn (I_r = 0.58) in biochar.

The study concludes that biochar from waste co-pyrolysis is an effective metal adsorbent, particularly for Pb. Due to the high stability of adsorbed metals, this biochar has potential applications in water, wastewater and soil remediation.

Keywords: straw; woodchips; biochar; metal adsorption

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Analysis of economic and social aspects of water reuse

Sustainable water management is an important issue in the environmental policy of the European Union. One practical example is water recovery from various streams, such as grey water, municipal sewage or rainwater. Water recovery technologies require a comprehensive assessment taking into account various criteria (environmental, social and economic). This paper aims to present selected techniques that can be used to conduct economic and social assessments of water recovery and reuse technologies. The economic assessment can be conducted with the use of life cycle cost (LCC), while social assessment can be realized via social life cycle assessment (S-LCA). Both of these techniques are used in the environmental management of enterprises and require data inventory and data analysis. Paper also presents an example of the use of LCC for analysis of gray and rainwater reuse in a four-person single-family house in Rzeszów in the period of 15 and 20 years of installation operation (based on literature review). Research shows that the longer the period of operation of a water recovery and reuse installation, the greater the profitability of its use compared to a traditional installation. The European Commission is working on a common framework for conducting environmental, economic and social analyses, so it can be expected that these methods shall further develop in the coming years.

Keywords: water reuse; economic assessment; social assessment

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Iceland Liechtenstein Norway grants

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Antibacterial activity of biochar with adsorbed zinc and copper ions

The aim of the research was to develop a concept for obtaining, modifying and shaping the antimicrobial activity of biochar produced from waste plant biomass in terms of its potential applications in various industries. As part of the research, waste apple biomass, which was a raw material after supercritical extraction, was used to produce biochar. Pyrolysis with steam activation was carried out at operating temperatures of 600, 700 and 800°C. Biochars with a developed specific surface and a predominance of micropores were obtained. The produced biochars did not have functional groups, which was probably due to too high a pyrolysis temperature. Analysis of the Raman spectra showed the presence of two characteristic bands: G, defining the graphic structure, and D, called the defect band. It was observed that as the pyrolysis temperature increases (regardless of activation), the degree of structure disorder increases. The efficiency of removing Zn^{2+} ions was lower than that of Cu^{2+} and depended on the specific surface area of the biochar. The removal of ions from the aqueous solutions by the produced biochars probably occurred due to intermolecular interactions involving van der Waals forces between the adsorbate molecule and the surface of the adsorbent and the packing of ions inside the micropores. It has been shown that the packing of Cu^{2+} and Zn^{2+} ions in micropores based on physical adsorption allows their free diffusion into the substrate, which results in limiting the growth of Escherichia coli and Staphylococcus aureus.

Keywords: biomass; pyrolysis; biochar; sorption; antibacterial

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Application of thermogravimetric and FTIR analysis to identify microplastics in environmental samples

The aging process of polystyrene and poly(ethylene terephthalate) allowed for the assessment of the impact of aging factors on these materials. The subject of the study were 4 samples of pure polystyrene and 4 samples of pure poly(ethylene terephthalate). For this purpose, a simulation of the aging process occurring in the environment was performed. The samples were placed in 30% H_2O_2 and irradiated with UV-A/UV-B light for 30 minutes. The samples were subjected to thermogravimetric and FTIR analysis before and after the aging process for comparative purposes. Research has shown that both materials degrade as a result of the aging process, and the degradation rate varies depending on the type of material. Polystyrene was more susceptible to aging compared to polyethylene terephthalate. FTIR analysis has proven to be an effective tool for assessing chemical changes occurring in polystyrene and poly(ethylene terephthalate) during the aging process. Characteristic absorption peaks were observed in the FTIR spectra, indicating the degradation of polymer molecules. The FTIR analysis results confirmed the presence of aging-related functional groups such as carbonyl groups, hydroxyl groups, and unsaturated groups. Thermogravimetric analysis allowed us to examine the effect of aging on the thermal stability of polystyrene and poly(ethylene terephthalate). A decrease in the degradation temperature and an increase in the mass of losses accumulated as a result of aging were observed. The results indicate structural changes and loss of thermal stability during the aging process of both materials, leading to microplastic emissions.

Keywords: microplastic; aging process; thermogravimetric analysis; poly(ethylene terephatalene); polystyrene

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Application of the liquid membranes in the selective nickel and cobalt extraction from wastewater

Cobalt and nickel are transition metals, which have application in various field and industries, such as production of alloys, batteries, and catalysts as well as in electroplating industry. Both of these metals are ductile, malleable and melt at high temperatures. Together with iron, they form a group of metals characterized by ferromagnetic properties. Due to their position in the periodic table of elements their chemical and physical properties are very similar. Therefore it is difficult to selective separate nickel(II) from cobalt(II) by using conventional separation methods in a simple and economical way. Nickel(II) and cobalt(II) can be separated by solvent extraction, however in the last decades the application of the liquid membrane technology for the recovery of transition metals from wastewaters has a growing potential.

Therefore, the objective of this work was to review the effectiveness of the liquid membranes application in the selective nickel(II) and cobalt(II) extraction from wastewater. The few types of liquid membranes such as supported, emulsion and hollow fiber liquid membranes were reviewed. Moreover, their advantages and disadvantages were discussed.

It was found that the liquid membranes allow to recovery of above 85% of cobalt with high selectivity over nickel. It was also found that the important variables governing the nickel and cobalt permeation were membrane composition, composition of the feed solution, mixing speed of solutions, concentration of extractant and pH of the feed. It was concluded that liquid membranes method can be relatively efficient in selective nickel and cobalt separation, but the long-term stability of membranes is not successful satisfactory.

Keywords: cobalt and nickel recovery; liquid membranes; membrane processes

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Assessing the ecotoxicity and microbiological state of waste from waste from sewage treatment plants

In sewage treatment plants, waste sand may have two sources: the content of the sand trap and the effect of cleaning the sewage system. The management of this type of waste causes operational problems and constitutes a financial burden. According to the concept of a circular economy, waste should be viewed as raw materials. Recovery of by-products is a circular economy business model that could be implemented at sewage treatment plants. However, in order for waste sand from sewage treatment plants to be considered a by-product, it must meet certain conditions. The aim of the project was to assess the toxicity and microbiological condition of sand produced in the sewage treatment process. The research was carried out in a selected sewage treatment plant with a maximum daily capacity of over 300,000 m^3/d. Sand was collected from three places: the contents of the sand trap, sewage cleaning and storage place (pile). As part of the project, toxicity analyses of aqueous solutions from the tested sands were carried out. Tests were carried out on saltwater bioluminescent bacteria - Aliivibrio fischeri, freshwater crustaceans - Daphnia magna, and vascular plants - Lemna minor. Based on the results of toxicity analyses, it can be said that the tested sands do not pose a threat to the natural environment. However, the scope of microbiological tests included, among others, the titer of the coliform group on the Eijkman liquid lactose medium, the titer of fecal coliform on the liquid lactose medium with ox bile and brilliant green, the determination of the presence of Staphylococcus aureus on the Baird-Parker selective medium, etc. From the microbiological point of view, the tested sands should not constitute epidemiological threat.

Keywords: waste; sewage treatment plant; sand; toxicity; microbiological state

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Development of a concept for closing the water cycle in the metal industry

Implementing the assumptions of the New Green Deal, i.e. achieving climate and raw material neutrality by 2050, requires the transformation of the entire system of production and consumption. Applying the principles of the circular economy in water and wastewater management requires developing system solutions, primarily in the field of recovery and reuse of water contained in wastewater, as well as their immediate implementation in enterprises.

The presented work concerns the possibility of purifying post-industrial wastewater generated by metal industry enterprises using membrane techniques. Wastewater generated during vibroabrasive machining of zinc-aluminum alloy details was examined. The research was carried out on a laboratory scale. An ultrafiltration process (pressure of 4 bar) and a polyacrylonitrile membrane were used. Filtration through a bag filter (pore diameter of 5 μm) was used as a preliminary purification step. Membrane filtration removed all suspension and reduced turbidity by 99.8%. Moreover, COD, TOC, total phosphorus content, anionic and non-ionic detergent content were reduced in the range of 86–97%; concentration of organic acids by 58% and dry matter by 48%. Wastewater treated in the technological system proposed in this work meets the requirements specified in the Regulation of the Minister of Construction for industrial wastewater that can be introduced into sewage facilities, however, the total reduction of suspended solids and the levels of other parameters indicate that the recovered water can be introduced into a closed circuit and used in the primary technological process.

Keywords: membrane filtration; wastewater treatment; closed water circuit; metal industry

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Sustainable manufacturing with Binder Jet 3D printing

Binder Jetting is a relatively new 3D printing technology that is increasingly being used on a large scale in various industrial sectors. Many aspects of the technique also translate into its use for manufacturing biomaterials. The goal of the project is to design a new composite biomaterial system based on titanium and hydroxyapatite with enhanced properties, by using Binder Jet 3D Printing, which could be used for surgical implants.

Binder Jetting has several benefits that translate into an eco-friendly process. The method proposes very high printing efficiency. The simultaneous powder distribution and binder application used significantly accelerate the printing process. An important consideration in this process is material savings. Excess powder that was not used during printing is recovered and, in turn, reused. This results in a significant reduction in waste. The presented technology is also characterized by versatility in the use of materials. Binder Jetting allows printing not only from one type of material, but makes it possible to print from ceramics, steel, or carbides. This translates into the use of just one machine for many applications. With the help of the presented method, we can fabricate structures of very complex shapes, without the use of additional technologies. It should be noted that during one process we are able to produce multiple parts, not just one, which makes the process more efficient.

The presented method's advantages suggest that Binder Jetting may offer an excellent alternative for manufacturing bone biomaterials, impacting not only ecological aspects, but also other methods of biocomposite production.

Keywords: reuse powder; Binder Jetting; 3D printing; eco-friendly; biomaterials

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Novel approach for chromium tanning waste valorisation to achieve circular economy concept

The paper presents the concept of a new technology for the valorisation of solid waste generated during tanning of hide using chromium tannins. Novel approach assumes the use of an integrated system of the thermal hydrolysis process and membrane filtration techniques for the recovery of chromium compounds and the use of separated organic matter during anaerobic fermentation. According to the assumptions of the developed technological concept, in the first stage, the crushed mixture of chromium tannery waste is decomposed in the process of thermal hydrolysis using appropriate process conditions in an alkaline environment. Then, the liquid product of this process (hydrolysate) is processed using centrifugal separation and the ultrafiltration process. Such activities enable the recovery of chromium compounds for dressing raw leather and the concentration of organic matter (fats, proteins) for energy use. Research carried out in operating conditions similar to real ones proved that chromium compounds recovered from waste can be successfully used in the treatment of cowhides intended for the production of footwear. In turn, the efficiency of biogas production from organic matter concentrate is comparable to the efficiency of fermentation of corn silage, which is one of the main biogas substrates. An industrial implementation of the developed technology for valorisation of chromium tanning waste would enable the transition from a linear economy to a circular economy.

Keywords: tannery wastes; thermal hydrolysis; membrane processes; recovery of chromium; biogas production; circular economy

Acknowledgments: The work was created as part of the project "New valorisation pathway form chromium tanned leather residues by a combination of protein extraction, chrome recovery and biogas production" (Acronym: LeatherProBio) co-financed by the National Center for Research and Development under the Cornet Initiative (Agreement No. CORNET/27/1/2019).

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Coffee grounds as a sustainable source for the production of fuel pellets

Coffee, being the most recognizable agricultural commodity worldwide, generates waste at every stage of its production. Awareness of sustainable consumption processes and the increasing biological utilisation of waste for energy purposes result in numerous applications of coffee waste. These include enriching biomass pellets, extracting bioethanol, or producing biodiesel from coffee oil. Enriched biomass is more energy-efficient, and the costs of obtaining such fuel are lower.

The aim of the study is to present the current state of knowledge regarding coffee grounds as a sustainable source for the production of fuel pellets. An analysis of the state of knowledge based on literature indicates that in the face of growing demand for renewable energy sources, pellet production has become one of the more popular ways to produce solid biofuels. Pelletized pellets, often made from biomass, are not only environmentally friendly but also an efficient source of energy. Coffee grounds can be an excellent, highly energy-efficient biofuel with a calorific value ranging from 15-19 MJ/kg. In recent years, special attention has been paid to these waste materials, primarily due to the significant amounts of organic substances that make up coffee grounds after brewing. These wastes contain cellulose, hemicellulose, lignin, among other components. They also exhibit a high carbon content, which varies depending on the type of coffee grounds.

Keywords: pellets; coffee processing waste; waste management; sustainable agriculture

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The application of unmanned aerial vehicles for greenhouse gas measurement: a comprehensive review

The work provides a comprehensive review of the utilisation of unmanned aerial vehicles (UAVs), commonly known as drones, for the measurement of greenhouse gases (GHGs). With climate change being a paramount global concern, accurate and efficient monitoring of GHG emissions is imperative for informed decision-making and effective mitigation strategies. Drones offer a promising solution to this challenge, presenting a versatile platform capable of collecting high-resolution spatial and temporal data in a cost-effective and environmentally friendly manner. The review begins by elucidating the pivotal role of GHG measurements in climate science and policy-making. Subsequently, it examines the limitations of traditional measurement methods and expounds on how UAVs address these challenges. The paper explores the diverse sensors and technologies integrated into drones for GHG measurement, encompassing infrared spectrometry, laser-based sensors, and thermal imaging. Furthermore, the review assesses the advantages and limitations of drone-based GHG measurement in various environmental settings, including forests, agricultural landscapes, and urban areas. It delves into the intricacies of data processing and analysis methodologies tailored to drone-generated datasets, highlighting emerging trends and future directions. The findings underscore the considerable advancements made in drone technology for GHG measurement, emphasising the potential for widespread adoption in scientific research, environmental monitoring, and policy implementation. The synthesis of current knowledge in this field not only provides a valuable resource for researchers and practitioners but also contributes to the ongoing dialogue surrounding innovative approaches to address climate change challenges.

Keywords: unmanned aerial vehicles (UAVs); greenhouse gas measurement; climate change; environmental monitoring; remote sensing

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Application of fenton's reagent and TiO_2/UV processes to decolorize aqueous solution of Reactive Red 241

Studies were carried out on the use of three advanced oxidation processes to decolorize an aqueous solution containing Reactive Red 241 (RR 241) dye at a concentration of C_0 = 100 mg/dm^3. This dye belongs to the group of reactive mono-chloro triazine azo dyes, which contains in its chemical structure -N=N- bonds built into the structure of aromatic rings. This dye is widely used in the textile industry for dyeing cotton, wool, and silk. Exposure to reactive dyes may cause cancer, kidney damage, nervous system damage, difficulty breathing, allergies, and skin diseases. Therefore, it is very important to effectively degrade these types of dyes contained in wastewater. In the tests, Fenton's reagent and the photocatalytic TiO_2/UV process using a low- and medium-pressure lamp were used to degrade RR 241. Using the most favorable process parameters, it was found that the highest dye oxidation efficiency was obtained in the Fenton process (99.854 %, C = 0.15 mg/dm^3), slightly lower for the TiO_2/UV process with a medium-pressure lamp (99.542 %, C = 0.46 mg/dm^3) and the smallest for TiO_2/UV with a low-pressure lamp (97.438 %, C = 2.56 mg/dm^3). It should be mentioned, however, that in all the processes used, the purified solutions were almost colorless.

Keywords: advances oxidation process; fenton process; TiO_2/UV; Reactive Red 241; decolorisation

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Preparation of polyethersulfone membranes using the wet phase inversion method

The National and EU legal standards emphasize the need for companies to pursue rational water and wastewater management strategies aimed at minimising water consumption and mitigating the impact of wastewater on aquatic ecosystems. The new polymer membranes, for wastewater treatment, based on polyethersulfone (PES) were prepared using a wet phase inversion method. The influence of solvents, non-solvents, presence of additives and coagulation time on the structure and morphology of membranes was investigated. Two types of solvents were used to dissolve PES (basic polymer) in the membrane-forming solution, i.e. N-Ndimethylformamide (DMF) and N-methyl-2-pyrrolidone (NMP). Polyvinylpyrrolidone (PVP) compounds were used as pore formers in the range of 0–5% w/w. The homogenisation of the membrane-forming solutions required the temperature to be increased to 40°C and 60°C for DMF and NMP, respectively. Moreover, studies have shown that the most favorable concentrations of PES and PVP in the membrane solution are 15% and 5% (w/w), respectively. A thin polymer film was obtained by casting the membrane solutions using an automatic machine applicator. Membranes with thicknesses ranging from 100 to 250 μm were poured onto a metal plate. The phase inversion process was carried out using demineralized water or a mixture of water and methyl alcohol. Carrying out the coagulation process for 60 minutes and adding 10% methanol to the coagulation bath had a positive effect on the structure. Experimental results showed that PES membranes with an asymmetric structure and the finger-like porous layer, which was confirmed by scanning electron microscopy (SEM), were successfully prepared.

Keywords: closed water circuits; membrane preparation; PES; wet phase inversion process

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Sustainable process of obtaining composites by powder metallurgy

Powder metallurgy technology is ecological and energy-saving. The elements are manufactured in a loss-free manner, with almost complete use of the powder used. Moreover, it should be noted that a big advantage is the energy saving of the process, which results from the use of a much lower temperature compared to casting. Manufacturing process allow to produce diverse products and components in both simple and complex shapes using a wide range of metal powders and alloy material blends. It is worth noting that powder metallurgy is sustainable, as the often used metal powder that a manufacturer starts with is often made from recycled scrap. It should be noted that this method is widely used in various industries including additive manufacturing, automotive, tooling, chemical etc.

The aim of the study was to create the titanium alloy- ceramic composites with potential use as a biomaterial. The paper presents cold isostatic pressing parameters for creating Ti6Al4V-hydroxyapatite samples. What is more the research include different ratio of the mentioned materials. The entire chain of technologies developed in the project are ecological, clean processes, using no harmful gases and do not produce waste. The proposed synthesis and characterisation methods are entirely ecologic and do not have a negative effect on the environment. The selected method of creating composites allows obtaining samples that can be sintered in a high-temperature furnace, assuming different ratios of ceramics to the metal alloy.

Keywords: powder metallurgy; sintering; powder pressing; titanium alloy; composites

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Artificial intelligence in energy sector – current state and perspectives

In recent years, Artificial Intelligence (AI) has been increasingly used in various sectors of the economy, including the energy sector. Currently, the following technologies are being used in the energy sector: AI and machine learning, intelligent energy networks, Smart Grid, Smart Metering and virtual power plants. There are also plans to implement blockchain technology for managing and automating energy transactions, along with the Internet of Things (IoT) aimed at achieving better energy efficiency. Opportunities to use AI in the energy sector include preventing energy theft. However, there are also potential threats, such as an increase in cyber-attacks due to the older software architecture compared to other sectors like finance. Nevertheless, Artificial Intelligence offers significant efficiency and performance benefits compared to current solutions on the market and can contribute to optimising the use of energy resources.

The aim of the work is to present the current and future possibilities of using artificial intelligence in the energy sector and to present the opportunities and threats that arise from them. An analysis of the literature was carried out and on this basis it was found that AI is dynamically developing in the energy sector. The biggest opportunity is to improve the efficiency of energy management in the market. However, the main threat is the increase in potential cyber-attacks.

Keywords: artificial intelligence; energy sector; cybersecurity; smart grid

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Effect of seawater on concrete elements

Concrete is the basic material for the erection of cubic, industrial, engineering structures, as well as hydraulic engineering structures and those working in a marine environment. Unfortunately, the impact of an aggressive environment such as seawater does not favorably affect the concrete structure. For this reason, the subject of the research undertaken was a preliminary assessment of the durability of concrete structures exposed to seawater.

The types and degree of concrete damage that occurred were analyzed, demonstrating the usefulness of surface morphology studies and SEM imaging in this assessment. The experiment focused on exposing cubic samples of ordinary concrete of C45/55 and C60/75 classes to seawater for a period of 365 days. The seawater came from the Baltic Sea from the area of Władysławowo. Due to the higher chloride and sulfate content of the seawater, sulfate corrosion and chloride corrosion occurred simultaneously.

For comparison, the samples were also stored in tap water and distilled water. Then, the compressive strength of the samples was tested, and their surface morphology was analyzed by measuring roughness parameters.

It was shown that the compressive strength of samples stored in seawater was 13-26% lower than that of reference samples, which were regarded as samples seasoned in tap water. Samples stored in distilled water had compressive strengths 5.7-15% lower than reference samples. As the concrete class decreased, there was a decrease in the concrete's resistance to the aggressive medium. In addition, analysis of SEM images confirmed, the ongoing destruction mechanisms caused by the recognized chloride and sulfate corrosion.

Keywords: concrete; chloride corrosion; sulfate corrosion; environmental protection; microscopic analysis

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Update of the EU Wastewater Directive in terms of micropollutants removal

EU Directive No. 91/271/EEC of 21 May 1991 regarding municipal wastewater treatment was developed over 30 years ago. The proposed changes include protection of the aquatic environment, improvement of sewage disposal and treatment systems, monitoring of micropollutants important for human health and the energy balance of sewage treatment plants. Sewage collection will include individual systems and third- and fourth-degree treatment. For large sewage treatment plants, there will be an obligation to use additional treatment processes to remove micropollutants and microplastics. Micropollutants belonging to the group of pharmaceuticals and cosmetics are mentioned. It should be emphasized that the mentioned groups of micropollutants include several thousand active compounds, the identification of which is difficult at the current stage of analytical possibilities. Pharmaceuticals include non-steroidal drugs such as: analgesics, anti-inflammatory drugs, antidepressants, beta-blockers, lipid regulators and antibiotics, as well as steroids (hormones). The group of personal care products includes fragrances, UV filters, disinfectants, preservatives, microplastic and nanometal particles. Microplastics pose a threat not only due to the presence of particles but also in terms of leaching plasticizers, dyes, antioxidants, hydrocarbons, phthalates, phenolic and acrylic compounds. Due to the large number of ingredients in the above-mentioned preparations, it will be necessary to identify specific compounds to monitor impurities important to human health. Additional processes will be necessary to effectively remove these compounds in treatment plants. Therefore, the requirements related to the implementation of the update of the Wastewater Directive will be an analytical and technological challenge.

Keywords: wastewater directive; pharmaceutics; personal care products

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Recovery of biogenic raw materials from sewage sludge

Currently in Poland, water and wastewater utilities are preparing to implement the idea of circular economy, in line with the policy outlined by the European Commission in 2015. Among other things, pilot plants for the recovery of raw materials or the recovery of water from wastewater are being set up, with not only ecological but also economic justification. The development of more efficient methods of recovering nutrients from sewage sludge, can have a positive impact on environmental protection and accelerate the pursuit of sustainable development. In addition, efficient recovery of phosphorus and nitrogen compounds can help reduce the cost of fertilizer production. The aim of this study was to develop the most favorable conditions for the recovery of phosphorus compounds and nitrogen in the form of struvite from dewatered sewage sludge and sewage sludge ash from three wastewater treatment plants. In the study, a wet method was used in which, an alkaline environment is used, to digest struvite - $(NH_4)Mg[PO_4]$ - $6H_2O$, the most favorable form of phosphorus bioavailable to plants. Struvite crystallisation studies were performed on a laboratory scale with the variables: pH, concentration of ammonium ions NH^{4+}. concentration of magnesium ions Mg^{2+}, at which struvite precipitation occurs. In addition, different concentrations of hydrochloric acid (0.2M, 0.4M, 0.8M) were used for the leaching reaction. It was shown that struvite precipitates at large variations in the concentration of ammonium phosphate compounds and magnesium. The essential influence is the pH, at pH above 9.0 at almost any concentration of ammonium and phosphate, struvite precipitation can be expected if there is sufficient magnesium. The reaction conditions used in the study: constant volumes and concentrations of solutions, pH=10 provided a surplus of substrates for struvite precipitation. Based on the results, it was concluded that in order to maximize the efficiency of the recovery process of biogenic raw materials, it is necessary to develop reaction steps and conditions for a specific substrate in each case.

Keywords: biogenic raw materials; phosphorus; nitrogen; sewage sludge; ash; recovery

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Use of water resources and wastewater management in Poland

Compared to the European Union countries, Poland is a water-poor country. Due to climate change, we are observing an increasing water deficit in rivers. The lack of retention reservoirs causes large variations in its resources. In 2021, the average annual waste was 640 mm, which was normal or below the norm compared to previous years. Water withdrawals have not changed significantly in the last 20 years. The largest amount of water (68%) is still consumed by industry, 23% by municipal economy, and about 9% of water is used to fill and replenish fish ponds. Water consumption for the needs of the national economy and population has decreased over 20 years. The liquidation of water-intensive industries and savings in water use by the population to the level of 100 dm^3/Md resulted in visible and noticeable trends in its use. The amount of wastewater produced also decreased. Despite the passage of time, there has been no increase in the number of sewage treatment plants (3,276 have remained at the same level since 2015). Significant changes have occurred in the method of managing sewage sludge, where currently the dominant use is for agricultural purposes and other purposes, e.g. construction. The article will present current issues regarding water resources in Poland, water consumption, the amount of sewage produced and sewage sludge generated.

Keywords: water resources; water consumption; sewage; sewage sludge

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Precipitation of struvite from supernatants separated from digested sewage sludge disintegrated with the papain enzyme

Removing nitrogen and phosphorus from wastewater is a necessary action to reduce eutrophication of surface waters. Recovering these elements from sewage and sewage sludge is of both ecological and economic importance. It is expected that global resources of phosphate deposits may be exhausted within 50-100 years. Most of the extracted phosphorus is processed into artificial fertilizers (approx. 80%), detergents (12%), animal feed (5%) and other products (3%). The most important recovered phosphate salts include calcium phosphates (mainly hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$, HAp and bruschite $CaHPO_4 \cdot 2H_2O$, DCPD) and magnesium and ammonium phosphates (struvite $MgNH_4PO_4 \cdot 6H_2O$, MAP - Magnessium Ammonium Phosphate). Removing phosphorus from wastewater can be carried out using many technologies. The most important technologies include the process of biological phosphate removal and chemical precipitation. The consequence of removing biogenic compounds from sewage is an increase in the amount of phosphorus and nitrogen in excessive sludge. There is also uncontrolled precipitation and accumulation of compounds containing these elements in various places in the technological process, e.g. from overlying supernatants containing high concentrations of nitrogen and phosphorus. This applies especially to the spontaneous precipitation of hydrated ammonium-magnesium phosphate. Controlled precipitation and crystallisation of sparingly soluble phosphate salts is a complex issue, both theoretical and practical. Temperature, pH, induction time and the presence of impurities have a decisive influence on the course and result of the process. Impurities can inhibit or catalyze the course of chemical precipitation reactions, closely integrated with the nucleation and growth of crystals, significantly affecting the shapes of crystals and the chemical purity of the product. The aim of the research was to determine the possibility of obtaining phosphate-magnesium-ammonium salts from overlying liquids separated from enzymatically disintegrated digested sludge.

Keywords: supernatants; sewage sludge; fermentation; enzymatic disintegration

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Studies of selected physicochemical properties of waste from wastewater treatment plants as an input raw material for the preparation of soil-like materials

A municipal wastewater treatment plant is a complex of technological devices and facilities used to remove pollutants contained in wastewater. Its operations generate a waste stream is generated, which can be divided into three types: screenings (code 19 08 01), sand trap contents (code 19 08 02) and stabilized sewage sludge (code 19 08 05). Each waste generated must be managed in accordance with applicable law. The waste produced in the wastewater treatment process is problematic for the treatment plant and represents a significant financial burden. However, when properly treated, the waste generated in the wastewater treatment process can become a valuable secondary raw material. In the new business models of the closed-loop economy, waste generated in wastewater treatment plants is seen as a nutrient-rich resource that can be used in the recultivation of degraded lands. The purpose of the study was to evaluate the physicochemical parameters of the waste, which could form the basis for the preparation of soil-forming material. The input material considered was excess sludge from the digester after the stabilisation process, sand from sand traps and sand after cleaning the sewage network. In the tested sludge the content of organic substances was 35%, organic carbon 12%, total nitrogen 1.8%, and potassium 0.24%. In the sands, the organic matter content was about 1%, organic carbon 1.8%, total nitrogen 0.5%, and potassium 0.02%. In the next research step, mixtures of sand and sludge (in proportions: 1:1, 1:2, 2:1) were prepared on basis of the research. The prepared mixtures were assessed in terms of their suitability for the recultivation of degraded areas.

Keywords: waste; municipal sewage sludge; sand; closed-loop; circular economy

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Microplastics and toxic substances in landfill leachate – analysis and treatment

Microplastics are reported as new and very dangerous emerging pollutants posing serious environmental problems. The problem of microplastics in landfill leachate was first identified in 2018, but until then only a few studies had been conducted in this area. The aim of the research was to analyze all possible contaminants present in "old landfill leachates". An analysis was carried out using a GCMS chromatograph to determine the occurrence of micropollutants, including pesticides. Microplastic analysis was performed by filtering leachate through meshes with a pore size of 250µm. The material retained on the filter was analyzed using a microscope. The quantity, origin, color, shape and size of all plastic particles were determined. To reduce the presence of microplastics, low-pressure membrane techniques seem to be a promising method. The ultrafiltration process was carried out using the SEPA CF-NF membrane-plate module (cross flow). A commercially available flat ultrafiltration membrane with the symbol PT (polyethersulfone, molar mass limit of 10 kDa). Complete retention of microplastics was demonstrated, and the process efficiency was high. During 8 hours of system operation, when 50% of the incoming leachate was purified, the permeate stream decreased by 25%. Then, the adsorption process on activated carbon (AC) was used to remove the remaining toxic substances contained in the landfill leachate. Activated carbon from coconut shells came from used tap water filter cartridges. The AC was carbonized and then activated with KOH at a temperature of 800 ºC in a nitrogen atmosphere.

Keywords landfill leachate; microplastic; ultrafiltration; adsorption; organic compounds

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