



Mineral and Energy  
Economy Research  
Institute  
Polish Academy of Sciences

# 1st International Conference

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## Strategies toward Green Deal Implementation



14 - 16 DECEMBER 2020  
ONLINE

HONORARY PARTONAGE



Ministry of Climate  
and Environment



The National Centre  
for Research and Development

IGSMIE PAN



## Conference proceedings

**1<sup>st</sup> International Conference**  
**Strategies toward Green Deal Implementation - Water and Raw Materials**

**14 – 16 December 2020**





14 – 16 December 2020

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*Publishing House  
Mineral and Energy Economy Research Institute  
Polish Academy of Sciences  
Cracow 2020*

**ISBN 978-83-959215-5-1**



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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 specializes in the analysis and assessment of specific problems and phenomena related to the management of fertilizer 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 optimize the use of resources at the local, regional, national and international levels.

The division's work includes development of management strategies and recommendations (roadmaps) regarding the sustainable and circular management of fertilizer raw materials (from primary and secondary sources) with the identification of market, technological, legal, environmental and social conditions, developing strategies for preventing food waste at the stages of production and consumption. Team has experience in developing strategies for water protection against nitrogen and phosphorus pollution from anthropogenic sources, determining directions for counteracting eutrophication and recommendations for the management of waste from the water and sewage sector in the context of water, raw materials and energy recovery. The division conducts activities in the field of identification and assessment of saturation of soils and surface waters (lakes, rivers) with fertilizer components and development of the concept of environmentally safe fertilizers, based on model studies on the transfer of phosphates and nitrates to surface waters and soils. In addition, the division conducts research in the field of searching for new materials (including nanomaterials) that may be used in the processes of municipal and industrial wastewater and soils treatment.

Division of Biogenic Raw Materials participates in international projects (Horizon 2020, EIT Raw Materials, NAWA) 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, fertilizer and agri-food sectors.



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## Introduction

Climate change and environmental degradation present an existential threat to the world. In the face of the increasing number of people in the world, as well as the progressive degradation of the environment caused by human activity, taking action to protect the environment is a priority. Therefore, there is high importance of the implementation of the Green Deal Strategies, which aim to reduce climate change. They are crucial in the pursuit of sustainability, in which environmental, economic, and social aspects are integrated to ensure the survival of present and future generations.

Therefore, the purpose of the 1<sup>st</sup> International Conference on Strategies toward Green Deal Implementation – Water and Raw Materials (ICGreenDeal2020) is to present the issue of climate change and ways to prevent it through innovative solutions (technological, environmental, economic, and social) that can be implemented under the Green Deal Strategies. This Conference aims to provide the platform presenting multidisciplinary knowledge with high scientific and practical importance, where Participants from different fields of environment (scientists, entrepreneurs, education) can come together and collaborate. Transfer of knowledge and good practices can accelerate the implementation of the Green Deal Strategies, and through this contribute to improving the quality of the environment and achieving a balance between human activities and nature.

The 1<sup>st</sup> International Conference on Strategies toward Green Deal Implementation – Water and Raw Materials (ICGreenDeal2020) was held on December 14-16, 2020. Due to the coronavirus pandemic the Conference was organised as the virtual event (ONLINE).

This publication presents summaries of all papers presented at the ICGreenDeal2020. We would like to thank all Participants, including Scientists & Academics, Environmentalists, Nature Lovers and Green Innovators (entrepreneurs) for presentation of 150 papers in 14 thematic sessions during this 3-days online Conference. Together, we want to save the Planet!

*Dr Marzena Smol*  
*ICGreenDeal2020 Chair*



## GREEN DEAL STRATEGIES

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**Marzena Smol**

## *European Green Deal Strategies*

The European Green Deal (EGD) was presented as the new economic strategy of the European Union (EU) in December 11, 2019 by the European Commission (EC). The EGD includes an action plan to increase efficient use of resources through the transition to a clean and circular economy (CE), and prevent the loss of biodiversity and reduction the level of pollution. The main goal for the Europe is by 2050 to become the first climate neutral continent. To achieve this ambitious goal, the EC in recent months presented strategies for implementing the EGD, which are summarised in the current paper. Adoption of the European Industrial Strategy, a plan for a future-ready economy was presented on 10 March, 2020 and behind it, on 20 May, 2020, the “farm to fork” strategy to make food systems more sustainable and the EU Biodiversity Strategy for 2030 to protect the fragile natural resources on our planet, were published. On 8 July, 2020 adoption of the EU strategies for energy system integration and hydrogen to pave the way towards a fully decarbonised, more efficient and interconnected energy sector was announced. Subsequently, on 14 October, 2020, Renovation wave, Methane Strategy and Chemicals strategy for sustainability were proposed. In December 2020, European Climate Pact and European Battery Alliance were filled. In the coming months new restrictions related to specific actions on the proposed strategies will be presented by the EC. It has to be underlined that the EU plans provide financial support and technical assistance to help regions and countries that are most affected by the move towards the green economy, under the Just Transition Mechanism, which is a key support to help mobilise at least €150 billion over the period 2021-2027, to alleviate the socio-economic impact of the transition.

**Keywords:** *European Green Deal (EGD); European Union (EU); strategy*

**Acknowledgments:** *Research carried out under the Subvention of the Division of Biogenic Raw Materials at the Mineral and Energy Economy Research Institute, Polish Academy of Sciences.*



**Ludwig Hermann**

## *Sustained Action towards Carbon Neutrality and Sustainable Development Goals: Essential Elements of the Green Deal*

The European Green Deal (COM no. 640, 2019) is essentially a highly ambitious and comprehensive strategic package encompassing: transforming the European economy for a sustainable future, financing the transition (including by the € 750 bn NextGenerationEU recovery fund), a just transition (leaving no one behind), a European Climate Pact and positioning the European Union (EU) as a global sustainability leader. It aims for increasing the EU's climate ambition for 2030 and 2050, clean, affordable and secure energy, a clean and circular economy, energy and resource efficient buildings, accelerating the shift to sustainable and smart mobility, the 'Farm to Fork' strategy by designing a fair, healthy and environmentally-friendly food system, preserving and restoring biodiversity, and a toxic-free environment.

The objective of the European Green Deal is to turn the currently prevailing, parallel crises of global warming, loss of biodiversity (also referred to as 6<sup>th</sup> mass extinction), pollution of land, fresh water and oceans and excessive use of materials, while social cohesion and inequality being exacerbated by the COVID-19 pandemic, to an opportunity: for new jobs, values and equal chances. More than half of the € 1.8 tn Multiannual Financial Framework is assigned to sustainable modernisation with € 750 bn raised on capital markets and made available to the Member States in the form of loans and grants to recover from the worst damages left by COVID-19. By 2050, the EU economy must not emit greenhouse gases and social wellbeing must have decoupled from materials use. An ambitious roadmap sets milestones to be achieved by 2030 including the Sustainable Development Goals, curbing greenhouse gas emissions by 40%, and reducing nutrient losses and pesticide use by 50%. With the European Green Deal, the European Commission has set the pace for a steady and fast transition to a sustainable, circular economy. However, Member States must adopt expedient national policies, and this has still to be shown. At the time of writing this abstract the Multiannual Financial Framework and the Recovery Fund are blocked by Hungary and Poland and little evidence is provided that governments, even beyond those mentioned above, give preference to common European over – sometimes oddly construed - national interests. The outcome is still open: Europeans may find themselves by 2030 on the road to a digitalised, socially inclusive, and biodiverse continent or facing increasing devastation by natural and social disasters. The choice is to be made by European citizens and their governments.

**Keywords:** *European Green Deal; Sustainable Development Goals; toxic-free environment*



**Jacek Makinia**

*Water and wastewater management in the context of implementation  
of the Circular Economy concept*

A circular economy (CE) concept is in line with the sustainable water management in urban areas. In particular, there is a need to switch from viewing wastewater not as a threat to the public health and environment, but rather as a resource. This new paradigm of wastewater treatment is shifting wastewater treatment plants to “water resource recovery facilities”. There are a few resources to be recovered from wastewater, including water, nutrients (phosphorus - P and nitrogen - N), organic compounds, and energy. Technical solutions for N and P recovery are available at different technology readiness levels. For P recovery, there are more than 50 known approaches and 65 identified worldwide full-scale applications (2017). For N recovery in side stream, almost 50 different physical, chemical and biological techniques have been tested under laboratory and pilot-scale conditions. Gas permeable membrane technology has revealed the greatest potential to recover ammonia from wastewater as a fertilizer (ammonium sulphate). Energy recovery is especially important for decreasing the carbon footprint of wastewater treatment plants. The chemical energy contained in raw wastewater is much higher than the energy demand for wastewater treatment. Unfortunately, only a minor portion (several %) of this chemical energy could be recovered. In order to increase the recovery potential, a concept called “carbon redirection” should be considered. Its general idea is to direct more organic compounds contained in wastewater to anaerobic digestion and biogas production. Typically, about 60% carbon redirection is needed to balance energy recovery from biogas with energy needs for treatment. It should be emphasized, however, that not always achieving energy neutrality goes together with minimization of the carbon footprint.

**Keywords:** *energy neutrality; nutrients; resource recovery; urban water cycle; wastewater treatment*



***Majeti Narasimha Vara Prasad***

### ***Bioremediation and Bioeconomy***

Wide variety of natural resources is being exploited to meet the demands of growing population generating huge amount of waste and anthropogenic emissions. Concerns about clean environment are increasing in the wake of climate change. “Environmental Sustainability” is thus a subject of global importance in the contemporary world. Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.

There is pressing need for pollution abatement and there is an even more pressing need to create viable value chains from contaminated substrates especially in developing economies. Prevention of pollution and resource recovery involving a wide variety of biological interventions using biodiversity is an emerging area of science i.e. bio-based economy. Bioeconomy relates to the “invention, development, production, and use of biological products and processes”. Bioeconomy has the potential to sustainably enhance the global well-being. Bioeconomy focuses on biotechnology applications for the prevention of pollution and resource recovery, production of renewable resources, agriculture, forestry, healthcare and industry involving biodiversity. In this presentation, examples of aquatics, ornamentals, woody plants shall be discussed for their role in Bioremediation boosting Bioeconomy.

***Keywords:*** value chains; resource recovery; bioremediation; bioeconomy



## COOPERATION FOR CLIMATE

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**Monika Sady, Wioleta Galat**

### *Reporting social and environmental impact on Polish Universities*

Universities play an important role in creating social attitudes. They educate and inspire to undertake activities related to development and creation of mindful mindset. Even though they create many socially responsible solutions, reporting social and environmental impact is still not common among Polish universities. Whereas we discuss social responsibility or sustainability on universities, many of them strive to create indicators that would help them present undertaken actions. This situation is mainly caused by lack of indicators, which could be used to measure this impact.

The presented paper aims to review the socially responsible reporting practices of Polish Universities, with a special view on Cracow University of Economics' first university social responsibility report. Authors also present undertaken actions to adjust the next report to the 17 Sustainable Development Goals (SDGs) and Global Reporting Initiative (GRI) standards.

**Keywords:** *university; reporting; indicators; impact*

**Acknowledgments:** *The Authors would like to thank the Team for University Social Responsibility of Cracow University of Economics (SOU EK). Members of SOUEK were the authors of the presented report.*



***Izabela Ratman-Kłosińska***

***LIFEproETV: Towards an EU market wide recognition of ETV as voluntary environmental scheme for proving performance of green innovations***

With the European Green Deal's ambitious objectives, new environmental technologies are under a greater mandate than many other innovations to stay current or even anticipate the needs and obligations of industries in meeting the regulatory requirements or looking for new business opportunities. Therefore, the interest and investment in new environmental technologies is growing rapidly, but implementing these technologies is not just a simple matter of "stick it and forget it". Providers of new environmental technologies often fall into the trap where they allocate a lot of time and resources on obligatory compliance testing and little on proving the technology's innovation and environmental benefits of it delivers to the users. However, this approach works at cross-purposes, since unless the technology users are able to see and clearly understand the benefits of the innovation, the providers are not able to realize their return-on-investment. This is why proving in a credible way the claims on the performance of an innovative technology and its environmental added value is so pivotal to its successful market entrance. Environmental technology verification (ETV) is a voluntary scheme that provides all: from technology providers, regulatory bodies, authorities, investors, financiers with a streamlined approach to confirm the performance of innovative environmental technologies in an impartial and credible way so that they can clearly see the benefits. The aim of the LIFEproETV project is to promote this scheme and build a strong brand awareness, market acceptance and recognition of ETV on the European market. This will be achieved by creating an enabling policy environment for ETV and its use in public procurement, workshops, guidance and coaching activities for building capacity, skills and understanding of ETV among technology providers, buyers, policy makers and other stakeholders, providing resources of ETV knowledge and ETV promotion campaigns.

***Keywords:*** *verification; environmental technologies; innovation; scheme; promotion*

***Acknowledgments:*** *LIFEproETV project is co-financed from the EU funds of the LIFE programme, funds of the National Fund of Environmental Protection and Water Management and funds of the Ministry of Agriculture, Hungary.*

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***ElMoll Ahmad***

### *Circular Economy innovations: the potential solutions in water sector*

Industrialization and urbanization have contributed to the increase in greenhouse gas emissions and climate change has become a reality that humanity faces every day. Climate change, reflected in variations in precipitation and temperatures, has significant negative effects on the quality and availability of water resources, agriculture production and human health around the world. Indeed, 40% of shortfall in freshwater resources by 2030 coupled with a rising world population has the world careening towards a global water crisis. Recognizing the growing challenge of water scarcity (two-thirds of mankind will face water scarcity by 2025), the United Nations (UN) General Assembly has mobilized action that will help transform how we manage water. The limits of natural resources and the recent warnings about waste pollution are encouraging the development of a circular economy (CE). Therefore, a transition to CE could create significant synergies for the wide adoption of water reuse as an alternate water supply.

This presentation therefore examines opportunities with the transition to circular economy using an innovative system for the treatment of wastewater as well as the reuse of wastewater in agriculture. Therefore, we underline that irrigation offers real prospects for large-scale recovery of wastewater, helping to reduce the deficit and conserve water resources, and increase agricultural productivity.

Generally speaking, the increased demand for water for domestic, industrial and irrigation use will increasingly have to face the limits of this resource! On the other hand, water sources traditionally used for agricultural applications include groundwater and surface water. Therefore, using the Non-Conventional Water Resources (NCWR) including, desalination and properly treated municipal wastewater, can be an ideal solution.

However, the major role played by desalination technology in meeting the growing demand for water in selected regions where water is scarce, this technology is very demanding in energy and additional post-treatment will be necessary. For this, we focus on a concept of “Decentralized Wastewater Treatment System” (DWTS), that can contribute to wastewater innovations and help in improving water quality.

In the last part of this presentation, we demonstrate that the DWTS is an important solution for global water scarcity and climate resilience challenges and describe the benefits of DWTS as an innovative wastewater treatment system. We conclude, through the European project Aquacycle, that effective water reuse applications can deliver environmental, economic and social benefits.

***Keywords:*** *water; wastewater; sustainability; Circular Economy; treatment; reuse; irrigation; DWTS*





## SUSTAINABLE MANAGEMENT OF WATER AND RAW MATERIALS

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**Lata Rani, Jyotsna Kaushal, Arun Lal Srivastav**

*Bibliometric analysis of India and USA for published research in water science and technology*

Nowadays, providing safe and clean water have become one of the biggest challenges across the world because of water pollution. Water pollution rapidly increases primarily due to anthropogenic activities and worldwide research is being conducted to deal with it. Although, ample of the research papers have been published in the area of water science and technology to find some better solutions of this problem. In present study, published research papers with the same area of interest have been extracted from the online database of SCImago website to provide an idea of water research for the policy makers. In this study authors selected India and USA to compare the research in the area of water science and technology from 1996 to 2019. In 1996, India published 225 research articles in water science and technology and it has increased up to 1642 by year 2019. However, USA published 3050 and 8138 research papers in years 1996 and 2019, respectively. It has been observed that USA produced 13 times more research papers in year 1996 with respect to India and by the year 2019 this gap has been reduced up to 5 times only. Therefore, it can be inferred that in the above area the level of research has been increased in India. However, still there is a huge gap in the number of research paper publication between both of the countries and Indian decision makers should keep in mind these facts so that the gap can be decreased with better performance in the coming years.

**Keywords:** *bibliometric analysis; India; USA; Scimago; Water Science & Technology*

**Acknowledgments:** *Authors would like to thank Chitkara University, Solan, Himachal Pradesh 174103 (India), for extending its valuable support and the research facility for writing this research paper.*

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**Mohammed Talib, Sunil Kumar**

### *Analysis and ANN modelling of water quality parameters in upper Ganga river basin*

Surface water quality in India is degrading day by day due to various anthropogenic activities mainly at urban stretches. Ganga is one of the most polluted rivers in India because of its exposure to dense population and Industries. Ganga being more prone to pollution is selected as area of study. It originates from Gangotri glacier present in Uttarakhand and ends up falling in Bay of Bengal. The river passes from densely populated states like Uttar Pradesh, Bihar, Jharkhand and West Bengal. Per capita availability of water is very low because of high population in Ganga river basin that ultimately results in overexploitation of river water. Lack of management and river water monitoring is one the most significant reasons of increase in water pollution. The study is conducted with an aim of improving water quality monitoring by creating models using ANN technique and analysing situation of water quality by calculating Water Quality Index. Rishikesh, Kanpur, Prayagraj and Varanasi are chosen as sites for which analysing and modelling was performed. Three most primary indicators of water quality are biochemical oxygen demand (BOD), dissolved oxygen (DO) and chemical oxygen demand (COD) are also predicted in this study using ANN modelling technique with the help of MATLAB software. Backpropagation method was used for adjustment of weight to hit the target value. Monthly data of 13 water quality parameters from a decade (2009 to 2019) was used for setting up models of BOD, DO and COD. Optimization of model was done using RMSE values. The study also includes calculation of Water Quality Index (WQI) for the decade from which data was collected by analysing six water quality parameters that are pH, TDS, Total Hardness, Calcium content, magnesium content and BOD. WQI is a unique tool which gives water quality status in single term and hence converts complex data sets in easy and understandable form. Water quality was found best at Rishikesh and worst at Kanpur. Water from Rishikesh was the only suitable for drinking, water from all three remaining sites Kanpur, Prayagraj and Varanasi was unsuitable to drinking. The most optimised model out of 12 models made in the study was Varanasi-BOD model.

**Keywords:** *water quality; ANN; biochemical oxygen demand (BOD); dissolved oxygen (DO); chemical oxygen demand (COD); water quality index (WQI)*



***Anna Podlasek<sup>1</sup>, Aleksandra Jakimiuk<sup>1</sup>, Magdalena Daria Vaverková<sup>2</sup>, Eugeniusz Koda<sup>1</sup>***

***Monitoring and assessment of groundwater quality within selected landfill sites  
in Poland and the Czech Republic***

In order to protect the components of natural environment, each landfill must be properly secured and the monitoring program should be adopted. This study presents a comparative analysis of groundwater monitoring implemented at selected landfill sites in Poland and the Czech Republic. The main intention was to assess the groundwater quality with a special attention given to the levels and temporal changes of groundwater quality indicators measured in collected groundwater samples. The research was also intended to detect possible leakages of pollutants from the landfill body into the groundwater and further into the environment. The assessment of groundwater quality was based on a comparison of pollutants concentrations measured in collected samples with standards provided by environmental laws, including Polish and Czech standards. On the basis of the long-term monitoring period, it was revealed for the Polish landfill site that the groundwater quality is improving in time, especially due to remedial works applied. For the Czech landfill it was observed that the quality of groundwater is not negatively affected by the operation of the landfill, but in the immediate vicinity of the landfill the groundwater quality is significantly affected by the agricultural use of neighbouring lands. The results showed that the leachate did not leak outside the landfill, especially due to minimal concentrations of heavy metals measured in groundwater samples taken from the piezometers located in the outflow direction from the landfills.

***Keywords:*** *contamination; groundwater; heavy metals; reclamation*

***Acknowledgments:*** *This research was partially performed within the project supported by the National Science Centre, Poland, under a grant No. 2017/25/N/ST10/00909.*

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**Karol Langie, Kinga Rybak-Niedziółka**

### *Renaturalization of local rivers in city landscape, based on Sokolowka Trail Valley design*

Processes of restoration of water elements in cities involve a wide spectre of social, infrastructural, spatial and landscape factors, as the case of renaturalization of Sokolowka river exemplifies. The research field is a mentally significant part of Lodz, contextually bound with identity of the city structure. Main goal of the work is to inform about design process that focuses on both urban and environmental aspects of transforming the project site into environmentally sustainable area of recreational and touristic functions, at the same time addressing social issues. Main research theses involve methods of transforming the city landscape in order to create space that is ecologically resilient while maintaining optimal social attractiveness of the site, all being subject to legal and environmental determinants. The Lodz example was compared to similar enterprises in Europe. Findings presented in the research outputs can be applied as a universal conceptual framework and inform method of city landscape design of similar characteristics.

**Keywords:** *renaturalization; resilience; city landscape; urban ecological restoration; cultural ecosystem services*

**Acknowledgments:**

*Studium – Pracownia Architektury, Warszawa – Design Unit*

*Rafal Malinski – chief architect*

*Karol Langie – project architect*

*Maciej Kolendowicz – senior landscape architect*

*Grzegorz Rejniak – landscape architect*

*Zofia Sobolewska – architect*

*Mariusz Drabik – visualisation artist*

*dr Tomasz Kowalczyk – hydrology consultant*

*prof. Zalewski, European Regional Centre for Ecohydrology – feasibility assessment opinion*

*Municipality of Lodz, Department of Shaping Environment – Contracting Authority*

*Artur Celinski – public constultations conduction*

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**Paweł Jarosiewicz<sup>1</sup>, Maciej Zalewski<sup>2</sup>**

## *Upgrading the Ecohydrological Nature-Based Solutions towards Circular Economy – how to close the phosphorus cycle?*

Phosphorus (P) has a dual meaning to the implementation of European Commission Green Deal strategy. First, due to pollution it decreases quality of water resources, therefore undermines climate-adaptation measures and achievements of Water Framework Directive goals. Secondly, as a valuable fertilizing resource that is depleting, it is in the centre of Circular Economy (CE) interest with efficient reuse approaches. Although, new technologies of P recirculation have emerged in recent years they are omitting the river systems, a P-vulnerable spots of biosphere.

Ecohydrological Nature-Based Solutions (EH NBS), present a variety of tools for pollutants reduction, including P removal with Permeable Reactive Barriers (PRB) made of P-adsorbing materials, usually calcium-based rocks. However, currently used PRBs has certain limitations, therefore a new adsorbing material was proposed (BioKer) to:

- Decrease the weight of PRBs, to facilitate their exchange, after P-capacity limit is reached.
- Increase PRBs efficiency, through chemical structure optimization.
- Introduce the CE concept to the EH-NBS with P reuse.

The research and development goals were successfully achieved. PBR mass was reduced by 83,2%, from initial 2080 kg·m<sup>-3</sup> to 350 kg·m<sup>-3</sup>. Efficiency of adsorbent was increased by 45%, when BioKer was optimized with calcite and calcium hydroxide (CaOH). Reuse of P, was confirmed with preliminary tests, utilizing *Spinacia oleracea* plants in hydroponic system and pot test. Material was tested in both, laboratory scale and in the artificial stream under environmental conditions. BioKer has the potential to become a linkage between EH-NBS and CE, closing the P cycle in river systems and beyond.

**Keywords:** *phosphorus; circular economy; ecohydrology; nature-based solutions*

**Acknowledgments:** *Initial research and development of BioKer was conducted under the Inkubator Innowacyjności+ financed in the framework of Program Operacyjny Inteligentny Rozwój 2014-2020 (Działanie 4.4). Optimization of the BioKer and technology upscaling was performed under the Bon na Innowacje in the framework of Program Operacyjny Inteligentny Rozwój, Działanie 2.3. „Proinnowacyjne usługi dla przedsiębiorstw”.*

*BioKer was awarded with the gold medal from Concours Lepine in Paris, France in 2018.*

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***Kinga Rybak-Niedziółka<sup>1</sup>, Magdalena Grochulska-Salak<sup>1</sup>, Eliza Maciejewska<sup>2</sup>***

*Resilience of riverside areas as an element of the Green Deal strategy -  
evaluation of waterfront models in relation to re-urbanization and the city  
landscape of Warsaw*

Riverside management and city water retention are an important issue in the Green Deal implementation strategy. The research work concerns the issues of shaping riverside areas in the face of climate change and crisis situations to ensure the implementation of social and ecosystem services in the city landscape structure. Moreover, it refers to the development of blue infrastructure in the city landscape in order to create a model of resilience of riverside public spaces and open areas transformed in the process of re-urbanization. An evaluation of the various areas of the Vistula river water fronts within the administrative boundaries of Warsaw is presented. The left-hand areas were designed as re-urbanization based on the hardened regulation of the quay on the tunnel slab and an underground station, interfering with their natural structure ("Warsaw Boulevards"). On the right bank, solutions from the waterfront naturalization category are used, providing ecosystem services and biodiversity ("Praga Route"), contrasting with new area full of cubature investments ("Praski Port"). Most of the riverside areas in the city have not yet been developed and require the creation of a comprehensive model that takes into account resilience in spatial progress. For this purpose, the spatial conditions and solutions for Warsaw were analyzed and compared with examples of selected European cities. As a result, a model was developed for implementing the assumptions of the Green Deal in the design and transformation of riverside areas in the city, including the urban, landscape, social and environmental context.

***Keywords:*** *waterfront; water retention; blue infrastructure; resilience; re-urbanization; city landscape; Green Deal*

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**Kinga Kimic, Karina Ostrysz**

### *Assessment of green and blue infrastructure solutions in shaping urban public spaces*

Cities dominated by impermeable surfaces face many challenges today. The development of green and blue infrastructure is a necessary measure to mitigate the negative effects of climate change, especially droughts and flooding caused by extreme weather events. The aim of the research was to assess the possibilities and limitations in the implementation of 19 green and blue infrastructure solutions commonly used in urban public spaces. A comparative analysis was carried out for each of them in relation to the three leading aspects including their main factors. From the nature perspective, the influence on lowering the temperature and air pollution, increasing the biologically vital areas, the share of vegetation, slowing down surface runoff, and impact for rainwater retention was taken into account. The spatial and functional aspects included ease of implementation and maintenance of each solution (including costs), its form and size, variety of functions and the possibility of combining with other blue and green solutions to make the complex system. The social aspects focused on decorative values, the possibility of social integration as well as participation in the implementation and maintenance of each solution. The results of the comparative analysis, based on literature review and the social survey (online questionnaire), were rated using the method of grading - assessed in each of the above-mentioned aspects, and then collectively. The highest scores were given to green and blue infrastructure solutions, such as: local bioretention lowerings, rain gardens, plant passages, absorbent ditches and hydrophytic ponds, scoring 30 or more points out of 38 possible. These solutions, due to their high values in each aspect, should be recommended for implementation in urban public spaces increasing their attractiveness and reducing storm water retention costs.

**Keywords:** *city; public spaces; negative climate changes; green and blue infrastructure; rainwater retention*





**Michał Preisner, Marzena Smol, Dominika Szoldrowska, Paulina Marcinek**

### *A toxic-free environment ambition in the light of the Polish Baltic Sea coastal zone pollution by heavy metals*

In the European Green Deal, the significant attention have been devoted to the reduction of anthropogenic pressure according to the toxic-free environment ambition. This cannot be achieved without limiting heavy metals emissions to the environment. Heavy metals are the largest threat for the sustainability of food sector because of how easily they are bioaccumulated by living organisms, especially aquatic species. Cadmium (Cd) and mercury (Hg) introduced to the food chain have proven to have a toxic impact on human health causing serious diseases such as the Minamata and Parkinson diseases, kidney and hearth failure, osteoporosis etc. Lead (Pb) is rarely transferred by the food chain but can be accumulated by humans from contaminated plants and water resulting in mental retardation and birth defects. Therefore, the current study analyzes the sources of the above heavy metals pollution in the Polish coastal zone of the Baltic Sea (Polish Exclusive Economic Zone - EEZ) which is a main fishing area for the Polish fishing industry. Available data on the riverine loads of Cd, Pb, Hg discharged by 12 largest Polish rivers to the Baltic Sea were analysed to show current trends of heavy metals contamination of aquatic species in 3 basins located in the Polish EEZ: Bornholm Basin (BB), Eastern Gotland Basin (EGB) and Gdańsk Basin (GB). The results show that in 2018 only species tested in the GB have achieved all 3 heavy metals values below the limit while in the BB and EGB the examined species have exceeded all 3 heavy metals limits.

**Keywords:** heavy metals; cadmium; mercury; lead; toxic-free environment; Baltic Sea; coastal waters; marine pollution

**Acknowledgments:** Research realised as the part of the project MonGOS “Monitoring of water and sewage management in the context of the implementation of the circular economy assumptions”, no. PPI/APM/2019/1/00015/U/00001/ZU/00002 (2020-2022), financed by the Polish National Agency for Academic Exchange (NAWA) under the International Academic Partnerships Programme. Web-page: [mon-gos.eu](http://mon-gos.eu).

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## SUSTAINABLE DEVELOPMENTS OF REGIONS

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***Agata Cieszewska, Renata Giedych***

*The European Green Deal - a chance for a positive transformation of undeveloped areas in Polish cities*

Undeveloped areas in Polish cities have a significant share. Among the 12 largest Polish cities, they occupy an average of 55% of the area. They are composed mainly of urban forests, water reservoirs and agricultural land. The latter are areas of uncertain future. Until recently they were treated as a reserve for new development. Their owners stopped to use them for agricultural purposes, as a result the share of fallow land in cities is growing. Recent amendments of spatial planning law indicated the necessity to adapt planning documents to the current demographic forecasts and economic conditions to build more compact cities. The problem, however, is how to use the leftover agricultural land in cities. In facing this may help a policy package under the European Green Deal. In this context, the new EU biodiversity strategy is of key importance. The aim of the urban greenery plan and the new forest strategy is to increase the share of forest areas in cities and to improve ecological connectivity. Another proposed action is the implementation of a clean energy program under the biodiversity strategy, which includes the reservation of open space for future investments in clean energy sources such as solar panel farms and sustainable bioenergy solutions. The future strategy for the protection of the built environment, which aims to protect soil resources also in cities, will bring about positive changes. The presentation aims to show how the European Green Deal strategy will actually contribute to the green transformation of Polish cities.

***Keywords:*** *green infrastructure; urban planning; European Green Deal; EU Biodiversity Strategy for 2030*



**Katarzyna Daniluk**

### *Implementation of the Zero Waste strategy in the food and beverage sector in Poland*

The paper touches upon the problem of the excessive production of waste in the food and beverage sector which results in wasting the resources and contaminating the environment. The zero waste strategy which is based on waste prevention, recycling and recovery of all resources and behavioural changes of the society is presented as a solution.

The study aimed at identifying the key actions which should be taken to implement effectively the zero waste strategy in Poland. The online survey method was employed to ask the particular groups of the society and some experts from different fields about their assessment of the particular solutions.

Disposable packaging of the majority of available products is a real problem for most of the questioned consumers and it makes them nervous. As the best solution they considered implementation of returnable packaging for food and beverage products all over the country and lowering value-added tax on products packed in an eco-friendly way. The idea of buying products to own containers was assessed lower.

Entrepreneurs were significantly less enthusiastic about any actions concerning changing the system of packaging. In regard to possible government policy, they assessed higher lowering CIT for enterprises implementing zero waste strategy in their businesses than government or European subsidies.

Experts in both economics and engineering agreed that implementation of ecology lessons in schools and campaigns raising ecological awareness for adults are necessary.

The findings of the research might be useful for policy makers to counteract the problem of waste in Poland.

**Keywords:** *waste management; zero waste strategy; waste prevention*



***Dominika Szoldrowska<sup>1</sup>, Marzena Smol<sup>1</sup>, Kari Ylivainio<sup>2</sup>***

*Awareness, attitudes and behaviours of farmers regarding the use of fertilizers  
from various waste streams*

Circular economy (CE) is a concept according to which materials and raw materials should remain in circulation as long as possible. One of the basic assumptions of CE is sustainable waste management. It is possible to recover major plant nutrients such as nitrogen, phosphorus and potassium from waste materials, which would reduce the use of chemical fertilizers in agriculture that have a negative impact on the environment and human health and would enable waste management in the fertilizer industry. Waste fertilizers are a renewable source of nutrients, so even if the limited reserves of critical raw materials for agriculture run out, the agricultural sector will be able to survive and correctly dosed organic fertilizers are more beneficial to the environment. This direction is in line with the CE assumptions.

The paper presents the review of attitudes and awareness of farmers to the use of various waste streams in agriculture, including sewage, sewage sludge, human urine and waste of animal origin. Farmers' opinion polls were conducted through face to face questions in the form of questionnaires in various parts of the world. Factors influencing the negative or positive attitude of farmers to this practice were identified.

***Keywords:*** *agriculture; farmers; fertilization; fertilizer from waste; waste management; circular economy*

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

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*Analysing public spaces for climate change resilience. Example of Grzybowski  
Square in Warsaw*

Crisis situations related to climate change and the current economic, social and environmental situation form the basis for analyses and transformations of the spatial structure in modern cities. The issues of adaptation to climate change and the Green Deal strategy, including the assumptions concerning climate neutrality, determine the conditions for the contemporary shaping of public spaces. The analysis of the urban morphology shows the relationship between the processes of reurbanisation and the problem of urban resilience, including this one related to climate change.

For the resilience of the entire urban structure, it is important to form "resilient nodes" - public spaces rooted in the urban fabric which represent solutions adequate for current and future needs.

In the presented research, studies on the transformation of a selected public space provide a basis for developing a methodology for analyses of climate change resilience. The results of the research concern the model describing the processes and determining the parameters which are relevant for defining possible directions of transformations and development of public spaces. The results of theoretical research are being used to carry out analyses of parameters in order to define universal values and recommended directions of transformations. The research summary includes interpretation of results and evaluation of analytical methods.

The research work discussed in the presentation is part of a comprehensive and multi-faceted research on the contemporary city and its possibilities of achieving broadly understood resistance.

***Keywords:*** *public space resilience; reurbanization; climate change; urban morphology; windflows*

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**Alexandros Stefanakis**

*Nature-based solutions for sustainable water management  
in the European Green Deal: examples and opportunities*

We realize today that the way our societies grow, consume, and waste natural resources is not sustainable. Natural resources such as water, energy, and nutrients, are becoming scarce, while climate change is proceeding. Rapid urbanization and overpopulation result in an increasing demand for water, underlying the importance of sustainable and resilience-based urban water management. The ultimate goal for a sustainable society dictates the need to identify tools to sustainably manage our water resources. However, the challenge is to understand the interconnections and synergies between technical and non-technical/social/management and economic aspects. Nature-based solutions (NBS) have been recognized as important tools in climate action, in addressing societal challenges, protecting and restoring ecosystems and supporting biodiversity conservation. NBS represent an attractive toolbox for sustainable strategies that can play a key role in the implementation of the European Green Deal. This presentation discusses the role of NBS in the new circular economy paradigm, where a modern holistic approach of water resources management is applied. Case studies and examples are presented to highlight the current knowledge and the role of NBS in the effort and desire of modern societies to accelerate their transition to sustainability.

**Keywords:** *nature-based solutions; water resources management; circular economy; sustainability; wastewater treatment*



**Magdalena Grochulska-Salak**

*Sustainable Urban Agriculture with Water Reuse in Re-urbanized Areas - Issues of Urban Resilience in the Green Deal Implementation*

The issue of water reuse and innovative water circulation solutions are important for sustainable urban agriculture. The aim of the research is the production of energy biomass and food in the city in re-urbanized and revitalized areas. The synergy between technologies of biomass production and water reuse is the basis for the idea of self-sufficient urban units. The areas and buildings for production are studied in the context of the development of innovative critical infrastructure and a model describing urban resilience. The research work defines the criteria of the urban resilience in relation to Climate Change. Urban agriculture is described as an element of implementing the Green Deal strategy in urban planning. The analyses concern the relation between production and management reuse of water. Presented results are part of the research on the resilience, critical infrastructure of the city and the model of self-sufficient urban units created in the process of re-urbanization. Described models and typologies of coexisting and interdependent agricultural production, renewable energy solutions and water reuse systems. Green Deal strategy should be connected with modern nodal areas and sustainable urban agriculture. Integrating production buildings and areas with green and blue infrastructure with water reuse technologies in circular economy processes. The discussion contains conclusions on the problem of autarky and synergy in urban planning, architecture and engineering solutions. Described the implementation technologies for city resilience in the context of agricultural production, energy and water management for local community and the ecosystem services in the city.

**Keywords:** *sustainable urban agriculture; water reuse; re-urbanization; urban resilience Green Deal implementation*





***Asja Mrotzek-Bloess<sup>1</sup>, Angela Binder<sup>1</sup>, Joanna Kulczycka<sup>2</sup>***

***Potentials for former mining regions to contribute to the principles of  
Circular Economy and Green Deal***

Recovering and transforming mining regions and related cultural landscapes represent nowadays one of the main paths towards the regeneration of structural weak peri-urban and rural areas. The decrease in mining activities in the last century has contributed to a reduction of economic activities, closure of related industries, unemployment and migratory movement.

However, these mining and metallurgy regions with a long-standing tradition in the extraction and processing of ores combine core competences on the way to a circular economy. Transformation processes require support from different actors along the value chain and at various political and societal levels. Furthermore, these processes depend on the awareness and acceptance of the public. Public participation, stakeholder processes, wider society education are important elements for a successful implementation.

The presentation shows different examples, how mining regions could contribute to circular economy principles and to the Sustainable Development Goals. On the technical side, existing competences in metal treatment are needed to implement a sustainable handling with electric and electronic products to raise the collection quota and to recover valuable metals from the devices. This could be a further (regional) supply source for critical metals. Obstacles such as hoarding old electric equipment at home can be tackled by educational approaches and public participation.

Another valuable contribution to educate sustainability and raw materials issues is made for example by mining museums. For example, the museum and exhibition mine Rammelsberg (cultural heritage) is both research partner and educational institution to impart knowledge about raw materials to a broad public.

***Keywords:*** Mining regions; Circular Economy; recycling region; Public participation; wider society education; cooperation

***Acknowledgments:*** We would like to thank the National Academic Exchange Agency NAWA for supporting the project COOPMIN.

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***Mapping stakeholder interactions for designing and implementing  
Circular Economy policies in regional contexts***

Addressing climate and environmental-related issues has become the focal point of discussion in the new global economy, and it is this generation's defining task (European Commission, 2019). In order to accomplish that, the entire socio-economic system must be transformed, whereby the circulation of materials will ultimately contribute to economic, environmental and social benefits (Reichel et al., 2016). This can be achieved through a shift towards a more regenerative and circular economy (CE). The transition towards the CE entails systemic changes, implying involvement, alignment and cooperation of all stakeholders at all levels. However, debates continue about how best to achieve this. Additionally, far too little attention has been paid to developing models for mapping stakeholder interactions when designing and implementing regional CE policies. This study seeks to remedy these issues by analysing academic literature and relevant policy documents and making the first attempt to adjust existing models for stakeholder mapping in the regional CE scenario. The CE-centric Quintuple Helix (QNH) model is developed, which promotes the emergence and deployment of trilateral networks, hybrid organisations and development/co-operation platforms. This model adopts a balanced, participatory approach that requires a new constellation of stakeholders. Its foundations are built on the traditional industry-government-academia nexus and enlarged with the inclusion of the civil society sphere and the natural environment subsystem. The environment is represented as the nucleus of the model, inspiring and triggering actions by the remaining four subsystems. The model is then applied in several real case studies of regional CE practices.

***Keywords:*** regional circular economy; circular economy; stakeholders; quintuple helix model; policies

***Acknowledgments:*** This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Innovative Training Networks (H2020-MSCA-ITN-2018) scheme, grant agreement number 814247 (ReTraCE).

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WATER AND SEWAGE IN CIRCULAR ECONOMY  
Session of MonGOS project (NAWA)

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**Klara Ramm**

### *Good practices in the field of innovative methods of water recovery*

The dry summer of 2018 was a wakeup call for many parts of Europe. A competition for water between drinking water suppliers, agriculture and industry sectors appears more often and may increase.

It is very important to relieve the most valuable water sources (groundwater) by looking for alternative sources for other sectors. Water reuse for farming can be such an alternative. Another problem is the growing consumption of fertilizers by agriculture. Several countries have shown that using reclaimed water agriculture can use less of fertilizers. Some EU countries proved that reclaimed water can be used in protecting biodiversity: minimum acceptable flow, aquifers recharge, wetlands protection etc.

In June 2020, the Regulation 2020/741 of the European Parliament and the Council of 25 May 2020 on minimum requirements for water reuse was published. The regulation alone is not enough, and further steps are needed, such as:

- analyse and develop the best methods of water reuse,
- elaborate guidelines on risk management,
- build farmers' confidence in reclaimed water,
- analyse the relationship between the use of reclaimed water and fertilizers,
- build local cooperation between farmers, plant breeders and water utilities.

Our main goal is to organize and launch a local pilot project involving wastewater treatment plant and plant breeders. The pilot system will serve to test technologies and effectiveness of operations in accordance with the Water Reuse regulation. Elaboration of guidelines on risk management as well as costs and benefits analysis will provide a transparent background to develop water reuse systems in Poland.

**Keywords:** *water reuse; reclamation; irrigation*



**Anna Borowczyk-Kurasińska**

### *Biologically active filtration system supported by oxidation - Oxelia™*

Climate change, droughts and floods are putting increasing pressure on access to clean water. Its reuse is becoming an essential part of integrated water resource management to ensure adequate water supply for industrial, agricultural, commercial and residential purposes. Technologies and solutions already exist today to be implemented in water re-use projects tailored to the needs of end users and local regulations. One of them is Leopold Oxelia™ system. It enables water reuse, providing the best treatment technology available to protect human health in a sustainable way.

Utilizing the power of oxidation to improve the treatment process through BAC filtration, the Leopold Oxelia™ system decomposes and removes the most difficult contaminants. Leopold Oxelia™ is used in the treatment of both treated wastewater and retention rainwater. In each of these two cases we set different tasks to be performed during the treatment process depending on the input parameters of the device and the purposes for which the water obtained is to be used. In various configurations, on the basis of our devices, the process is individually selected for each application. Both ozone generators and UV lamps used, combined with biologically active carbon, are effective microbiological barriers.

The Oxelia system's oxidation step uses ozone and ozone-based advanced oxidation process (AOP), or UV-based AOP, to break down difficult organic carbon compounds into smaller, biodegradable components while providing an oxygen-saturated water. In the BAC step, naturally occurring microorganisms attach to the granular activated carbon (GAC) fixed bed filtration media, developing into a BAC. The microorganisms assimilate these partially oxidized organics, using the dissolved oxygen to complete the destruction of the total organic carbon (TOC). The result is a disinfected, biologically stabilized finished water much lower in contaminants, TOC, turbidity and suspended solids.

**Keywords:** *oxelia; waterreuse; waterwastereuse; oxidation; activefiltration*

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**Michał Bodzek**

### *Membrane separation techniques – removal of inorganic and organic admixtures and impurities from water environment*

Introduction and development of membrane techniques in the production of drinking water and purification of wastewaters, in the last 40 years, was important stage in the field of water treatment effectiveness. Desalination of sea and brackish water by means of RO is established way for drinking water production. Significant improvements in design of RO, the application of alternative energy sources, modern pretreatment and new materials have caused the success of the process. NF is the methods of water softening, because NF membranes can retain di- and multivalent ions, but not monovalent. Drinking water containing viruses, bacteria and protozoa, as well as other microorganisms can be disinfected by means of UF. Viruses are retain by UF membranes, whereas bacteria and protozoa using both UF and MF membranes. For the removal of NOM it is possible to use direct NF or integrated systems combining UF or MF with coagulation, adsorption and oxidation. The use of NF, RO and ED, in the treatment of water containing micropollutants for drinking and industrial purposes, can provide more or less selective removal of the pollutants. The very important are disinfection by-products, residue of pharmaceuticals and endocrine disrupting compounds. Endocrine disrupting compounds, special attention is paid onto polycyclic aromatic hydrocarbons and surface-active substances, chlorinated pesticides, phthalates, alkylphenols, polychlorinated biphenyls, hormones, synthetic pharmaceuticals and other substances disposed to the environment. The application of MF and UF in inorganic and organic micropollutants removal is possible in integrated systems with: coagulation, adsorption, complexation with polymers or surfactants and biological reactions.

**Keywords:** *membrane techniques; water desalination and softening; natural organic matter; removal of inorganic and organic micropollutants*



**Lise Appels**

*Anaerobic digestion as a key technology in a sustainable economy: current achievements and challenges*

Anaerobic digestion entails the conversion of organic matter into an energy-rich biogas consisting of ca. 65% CH<sub>4</sub> and 35% CO<sub>2</sub>, and is governed by a complex consortium of Bacteria and Archaea. It is generally considered as the preferable strategy for processing organic waste streams such as sewage sludge, manure and agricultural waste, since the biogas is valorised through (on-site) CHP applications for immediate heat and electricity production, or used as a replacement for natural gas, after biogas purification and drying. Thus, current biogas applications are focused on its properties as an energy carrier.

However, the use of biogas (or better, its CH<sub>4</sub> fraction) as a feedstock for the synthesis of renewable chemicals could possibly be a more valuable strategy. A variety of different concepts can be considered, such as (i) microbial or chemical conversion to methanol or formaldehyde, (ii) the oxidative conversion to ethane or ethane, (iii) the direct (catalytic) conversion to benzene, toluene or naphthalene using zeolites. Indirect conversion to renewable chemicals can also be employed: this includes reforming to syngas, from which alkanes and solvents can be produced via the Fischer-Tropsch reaction. Alternatively, methyl-tert-butyl ether, dimethyl ether, methyl esters can be formed via methanol as intermediate. Obviously, the production cost of these renewable chemicals will be the determining factor for the eventual market implementation of these molecules. This cost will depend on a.o. the cost of the digester feed, and the purification of the produced biogas prior to further conversion and the cost associated to the price of natural gas. Nevertheless, if biogas (or biomethane) can be sold as a valuable feedstock for the chemical industry, it will have a huge impact on the economic balance and profitability of full-scale digesters.

**Keywords:** *anaerobic digestion; sludge; methane; renewable chemicals; resource recovery*



**Bartosz Łuszczek**

### *Circular Economy projects in Cracow Water & Wastewater System*

The Cracow water and wastewater system is constantly developing. The obvious task is the security of water supply for residents and the sewage disposal and treatment. The Cracow Waterworks also conducts innovative projects focused on the circular economy in three areas: energy efficiency, water recovery, material and waste management. The development of energy sources based on biogas produced in wastewater treatment plants allows us to strive for energy self-sufficiency of our WWTPs. Water recovered from treated wastewater is used in Cracow for technological processes, washing sewers and street cleaning. We develop technology for the use of wastewater in a power plant. Our goal is to carry out waste management to recover valuable materials such as phosphorus, coagulants and construction materials. The phosphorus recovery project is focused on an optimal technology for Polish wastewater treatment plants. Our R&D centre is based on the research potential of the central laboratory, which we are constantly developing.

**Keywords:** *circular economy; water reuse; phosphorus recovery; energy efficiency*





## RAW MATERIALS FOR HEALTH CARE

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**Aditya B. Ankari, Sudhansu S. Choudhury, Sarada D. Tetali**

### *Pharmacological activities of Rosmarinus officinalis L. and its metabolites*

The pandemic Coronavirus disease (COVID-19) claimed 60.9M positive cases with 1.43M deaths. The root cause for the severity of illness is recognized as hyper-inflammation, further evident from patients' recovery upon treatment with anti-inflammatory drugs. Such results resurged global interest in herbal products and also prompted scientific investigations. Herbs enriched with antioxidants boost innate immunity and attenuate hyper-inflammatory response. Recent reports showed the efficacy of ursolic and betulinic acids against SARS-CoV-2. Ursolic acid containing *Rosmarinus officinalis* L., a medicinal and condiment herb, has been selected for the present study. Leaf/stem extracts of *R. officinalis* and its selected metabolites (rosmarinic acid,  $\beta$ -caryophyllene, limonene) are tested against free radicals and acute inflammation stimulated in human monocytic (THP-1) cells by bacterial endotoxin- lipopolysaccharide (LPS). At the maximum dosage of the metabolites (60  $\mu$ g/ml), >95% of cells were alive, determined by MTT assay. Aqueous and hydroalcoholic leaf extracts (WE/AE) of *R. officinalis* showed marked DPPH scavenging activity in the following order: Hot-AE>Hot-WE>Cold-AE>Cold-WE of dried leaves followed by fresh leaves and stem. Among the metabolites, rosmarinic acid showed the highest activity against DPPH radical as well as LPS stimulation. Compared to control, LPS induced THP1 cells showed a 22-fold increase in TNF- $\alpha$  secretion, whereas those pre-treated with rosmarinic acid showed only a 10-fold increase and limonene 14-fold; the effect of  $\beta$ -caryophyllene was negligible. These results support the antioxidant effect of *R. officinalis*, also the anti-inflammatory properties of its metabolites. Further research in this direction may result in developing plant-based therapeutics for the treatment of COVID-19 like diseases.

**Keywords:** *Rosmarinus officinalis*; 2,2-diphenyl-1-picrylhydrazyl (DPPH); Inflammation; THP1 cells; Tumor necrosis factor-alpha (TNF- $\alpha$ ); Antioxidant



**Madhuri Vajha**

### *Herbal medicine for corona virus disease (COVID-19)*

The hereditary material of Corona viruses is a (+) single stranded RNA, which is well-known with largest viral genome (27-32b) among the identified RNA viruses. In Corona virus, some part of RNA gets translated into two polyproteins. 3CLpro is 3C-like proteases or (3C(L)pro) are widely found in (+) ssRNA viruses, has a non-classical Cys-His catalytic dyad. 3CLpro exhibit self hydrolytic cleavage activity and release functional non-structural proteins (nsp4~nsp16) from these polyproteins by recognizing 11 sites specifically. These non-structural proteins play a role in life cycle of RNA viruses such as protein translation and nucleic acid synthesis. Therefore, the life cycle of viruses can be blocked by 3CLpro inhibitors. There is no vaccine or specific antiviral treatment for COVID-19, phytomedicines can be used as an alternative approach to minimise the risk of corona virus disease (COVID-19) followed by symptom management and supportive care.

Several plants exhibited immunostimulating activity against the Corona virus disease 2019. Plants and their phytoconstituents for immunomodulation have been described as a function of antiviral activities for e.g. *Artemisia annua*, *Citrus aurantifolia*, *Citrus Clementine*, *Citrus limon*, *Houttuynia cordata*, *Isatis indigotica*, *Lycoris radiate*. Antiviral mechanisms against Corona virus, such as inhibiting the viral 3CL protease and blocking the viral RNA-dependent RNA polymerase activity, involved in immunomodulation are explained. This information is useful to researchers for developing potential anti COVID-19 phytomedicine.

**Keywords:** RNA viruses; 3CL protease; immunomodulation; antiviral mechanism; phytomedicine



**Sailaja V. Elchuri**

### *Eco-friendly Nanomaterials for Eye Cancer Research*

Therapeutic drug delivery to eye for various diseases is challenging due to unique structure, physiology, and function of the eye and several nanotechnological approaches are available that could address this area. The delivery systems include non-metallic and metallic nanoparticles. Non-metallic substances include FDA approved polymers dendrimers liposomes and nanoemulsions. In metallic nanoparticles iron oxide nanoparticles and gold nanoparticles are used in diagnostics therapy in solid tumours. Currently there are no approved metallic nanoparticles for ocular diseases, especially eye cancer. Retinoblastoma (RB) is paediatric cancer that is prevalent in 1 in 15000-20000 births and is more fatal in developing countries and secondary tumours in number of organs such as lung bladder and brain are reported later in the life. There are very few targeted therapies for RB therapy. Eco-friendly gold nanoparticles (GNPs) fabricated from *Vitis vinifera* L. and Curcumin conjugated to therapeutic peptides exhibited efficacy. The biosafe preclinical evaluations should lead to novel therapy options for RB. The GNPs fabrication usually needs hazardous chemicals and plant based metallic nanoparticles are more environmentally friendly, compared to chemically synthesised nanoparticles. Additionally, there are no invitro eco-friendly cell culture models to grow RB cells in 3 dimensions for drug screening instead of going for expensive mouse xenograft models. To address this, we have fabricated scaffolds using FDA approved PDMS and bioinspired porous carbon from Palmyrah sprout. These scaffolds are less toxic than chemically fabricated scaffolds for RB cell growth. The Biosafe eco-friendly materials are a step towards finding targeted therapy for childhood eye cancers.

**Keywords:** *Retinoblastoma; 3D cell culture models; targeted therapy; green synthesis of nanoparticles; eco-friendly therapy*

**Acknowledgements.** *Grants from Department of Science and Technology – Nano Mission India (grant no. SR/NM/NS-83/2010) and Scientific and Engineering Research Board (EMR/2015/000607).*

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**Satyabrata Acharya, Ritwika Mohinta, Kazim Mohd, Nikhil Pt, Sarada Devi Tetali**

### *Inhibitory Activity of Medicinal Plant Extracts against Lipase enzyme and Inflammation (in vitro)*

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), an infective viral agent, caused a global pandemic. Studies have shown that people with unhealthy lifestyles, dietary habits, and comorbidities are more prone to succumb. Obesity increases the mortality risk of COVID patients as they are immune-compromised. Lipase enzyme inhibitors reduce gastrointestinal fat absorption and are used for treating obesity. Lipolysis products of triglyceride-rich lipoproteins (TGRL) generated by lipoprotein-lipase are pro-inflammatory and promote atherosclerosis by activating monocytic and endothelial cells. The present study aims to identify the medicinal plants with significant lipase inhibitory activity and antioxidant activity. We tested the lipase inhibitory activity of aqueous and hydroalcoholic extracts of the following selected medicinal plants: *Azadirachta indica* (leaf), *Carica papaya* (leaf), *Momordica charantia* (leaf and fruit) and *Rauwolfia serpentina* (root). A source of lipase used was porcine pancreatic lipase and orlistat as a standard inhibitor. Hydroalcoholic dry leaf extract of *A. indica* inhibited 40% activity of the enzyme, aqueous and hydroalcoholic roots extracts of *Rauwolfia serpentina* inhibited 49% and 69%, respectively. *Momordica charantia* showed moderate inhibition, followed by *C. papaya*. All the selected medicinal plant extracts showed significant free radical scavenging activity based on DPPH inhibition. The leaf extract of *A. indica* (AILE) and the root extract of *R. serpentina* (RSRE) were also tested for their anti-inflammatory activity using lipopolysaccharide (LPS) induced human monocytic (THP-1) cells for TNF- $\alpha$  release. AILE showed a higher attenuating effect compared to RSRE. Our results suggest *A. indica* and *R. serpentina* (RSRE) may further be explored for treating COVID like infections.

**Keywords:** obesity; lipase; medicinal plants; inflammation; human monocytic (thp-1) cells

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## BIOECONOMY

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**Silvija Dangėlaitė, Kliopova Irina**

### *Integrated Sewage Sludge Management: a case study in Lithuania*

In recent years, both in the world and in the EU, much attention has been paid to the proper management of sewage sludge by using its energetic and material properties. Up to 60 thousand tons of sewage sludge are generated in Lithuania every year. Most of it is anaerobically treated to produce biogas, the remaining digestate is dried and used for fertilization of energy crops or for co-incineration. The rest of the sludge is composted together with the green waste. As the requirements for composting sludge and the use of this compost in Lithuania are becoming more stringent, there is a high risk that most of the treated sludge will be incinerated, resulting in a loss of its nutritional properties. The aim of this study is to evaluate the possibilities of producing compost (a soil improver) from sewage sludge (digestate), which would comply with the requirements of the fertilizing product. The object of the research is Vilnius wastewater treatment plant.

The results of laboratory analysis of dewatered digestate samples showed that it characterizes a very high value according to the main quality indicators of fertilizing products. The risk arises due to Cd, Zn, Cu, Ni, the concentration of which is more than 2 times higher in comparison with limit values. The study was carried out in two stages:

- Applying a preventive approach: a detailed analysis of wastewater sources was performed, identifying the main potential pollutants of heavy metals;
- Using the principle of integrated waste management: alternatives for optimization of the sludge composting technology were analyzed.

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

**Keywords:** *sewage sludge; nutrients recovery; integrated waste management*

**Acknowledgements.** *We would like to thank the employees of the wastewater treatment plant UAB Vilniaus vandenys and the ecologist for the opportunity to analyze the processes and conduct the composting experiment.*



**Edgaras Stunžėnas, Monika Valančiūtė**

### *Implementation of Circular Economy principles by recovery of material properties from municipal sewage sludge*

The amount of primary resources in the world is declining drastically, for this reason, it is very important to develop safe technologies for the recovery of secondary resources from waste. In order to implement the principles of the Circular Economy in wastewater management, sludge must be analysed not as a waste but as a raw material for the production of new products. First of all, it is a very good alternative for sustainable energy production (in case of biogas production). However, in many large cities of Lithuania, it has been decided to dry the digestate after anaerobic sludge treatment to produce solid recovered fuel. Sludge has good nutritional properties that are not fully exploited during incineration. Most wastewater treatment plants transfer the dried sludge to fertilize energy forests. In Lithuania, the requirements for sludge management have significantly tightened, especially due to heavy metal concentrations, therefore will be no possibility to use of dried sludge for soil improvement since 2021.

This paper represents the results of investigation which was carried out in Kaunas municipal wastewater treatment plant in order to suggest alternatives for proper used nutritive properties of the sewage sludge. The main focus was dedicated for phosphorus recovery since this nutrient is critical raw material in Europe. It was found that the digestate centrate contains relatively large amount of orthophosphate phosphorus (240 mg/l). The implementation of struvite precipitation technology can allow producing 44 Mg per year of struvite (raw material for phosphorus fertilizers production), improving digestate dewatering properties, and reducing coagulant consumption needed for centrate treatment.

**Keywords:** *sewages sludge; circular economy; phosphorus recovery*





***Pinaki Dasgupta, Vivek Kumar, Anushree Malik***

## ***Wastewater treatment systems for city based municipal drains for achieving sustainability***

Currently, drains in several cities carry the load of rainwater as well as the untreated grey water and black water from settlements nearby. In emerging economies, cities often become hubs of illegal and unauthorised colonies which thrive in the vicinity of storm water drains. These create a unique pressure on the infrastructure as well as pose a challenge for civic bodies for ensuring adequate outflow quality as per environmental discharge norms. The flow characteristics (erratic, seasonal, minimum continuous flow) and structural constraints (the bed and site complexity) in the design of these drains restrict the options for implementing large wastewater treatment plants. In addition to the above, the designs which rely heavily on structural, mechanical and energy inputs are economically not feasible and demand more maintenance which acts as hindrances in these kinds of harsh environments. The aspect of human health is a critical factor in these scenarios as periodic exposure to sewage without any protective equipment during maintenance could lead to loss of good health and peace of mind.

The use of decentralised and distributed wastewater treatment systems offer an in-situ choice for achieving the desired result in quality and nutrient removal in the influent. These systems enable the water to be safely discharged to rivers or channelized for agricultural purposes. Further, solid fraction in the sewage could be extracted as manure or compost after curing. The selection, design and implementation with maintenance are essential for improved efficiency and productivity of the system. Therefore investigation into such systems utilised presently and few other possibilities are discussed in this paper. The main objective of this paper is to establish various technologies which could be adopted sustainably by municipal corporations for efficient treatment in limited boundaries of special and temporal choices offered by city drains.

***Keywords:*** *municipal drains; sewage management; circular economy; treatment systems; sustainability*

***Acknowledgements.*** *CRDT IIT Delhi, South and North Delhi Municipal Corporations.*

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**Refad Ahmed, Hemen Deka**

*Vermicomposting of Patchouli bagasse with addition of cowdung through the use of Eisenia fetida*

Increased demographic expansion with rapid urbanization significantly raises the seriousness of the bio-waste management. Vermicomposting is an effective, eco-friendly bioconversion process which justifies the environmental message for reduce, recycle and reuse of waste. In this investigation, vermicomposting potential of *Eisenia fetida* was studied on Patchouli (*Pogostemon cablin*) bagasse and cowdung mixture taking different experimental ratios. The vermicomposting duration was fixed for 50 days and the end products were evaluated on the basis of changes in physico-chemicals, nutrients, stability parameters such as humification and C/N ratios, ash contents and enzyme profiles. The results showed significant increase in macronutrients contents (N,P,K, Ca, Mg) and decrease in humification index and C/N ratios in all the vermicomposting treatments than the initial raw materials and traditional compost (without earthworm). Instrumental analysis such as Scanning electron microscopy (SEM), Fourier transform infrared (FT-IR) spectroscopy and X-ray diffraction (XRD) were also done to measure the maturity, stability and biodegradation of the initial feed mixture. Beneficial bacterial population were also evaluated and found to be increased in the vermicomposting end products. Earthworm population and biomass gain were also recorded in every treatment. Both conventional and advanced techniques represented the maturity and stability of the vermicompost.

**Keywords:** *Eisenia fetida*; Patchouli bagasse; C/N ratio; XRD; humification Index



**Glory Borah, Hemen Deka**

*Physico-chemical, biological and heavy metals (HMs) profiling of oil contaminated soil of Assam, India*

Crude oil contamination is considered a burning problem around the globe. The present study deals with the physico-chemical, biological and heavy metals (HMs) profiling of contaminated soil near the group gathering stations (GGS) of oil field of Assam, India. The GGS are the sites where crude oil is stored before sending it to the refineries and leakage/seepage of oil is evident around it. Total seven sites were selected for the study. Samples were collected at different distances such as 5 m, 10 m, 30 m, 50 m and 100 m from the main source of contamination (i.e. GGS). The physico-chemical parameters includes the analysis of pH, conductivity, water holding capacity (WHC), moisture content, total organic carbon (TOC), available phosphorus (AP), available nitrogen (AN), total potassium (TP) contents of the contaminated soil. On the other hand, the biological parameters include the estimation of urease, dehydrogenase, polyphenol oxidase, peroxidase, cellulase, amylase, phosphatase and catalase activities in the contaminated soil. The heavy metals (HMs) contents were analysed by Atomic Absorption Spectrophotometer (AAS). The results of the study showed deterioration in soil physico-chemical properties when compared with control counterpart. The enzyme activities of the contaminated soil sample were found to be significantly higher in case of urease, dehydrogenase, amylase, catalase and phosphatase. On the other hand, the enzyme activities of the contaminated soil sample were found lesser in case of polyphenol oxidase, peroxidase and cellulase. The heavy metals (HMs) profile in the contaminated soil has been found to exceed the permissible limit and thus gives a clear indication of metal pollution due to crude oil contaminations.

**Keywords:** *crude oil contaminations; heavy metal (HMs); physico-chemical; biological; changes*



**Shaleh Akram, Hemen Deka**

*Phytosociology and antioxidant profiles of selected herbaceous plants of crude oil contaminated soils of Assam, India*

Crude oil pollution is a worldwide problem and a major environmental concern. Heavy metals (HMs) such as Cu, Cr, Cd, Mn, Fe, Co, Ni, Zn, and Pb are major pollutants found in crude oil. The HMs exerts genotoxic, carcinogenic, mutagenic, and teratogenic effects on living beings. So, remediation of crude oil contaminated sites by eco-friendly and cheap methods such as phytoremediation are necessary. There are many century-old oil fields in Upper Assam, India. Crude oil pollution during drilling, handling, spilling, transportation, refining and others are very common in oil fields of Assam. The study area selected for this investigation was the Geleky oil field of Assam. This site is located between latitude 26° 47' 45.24" N and longitude 94° 41' 29.4" E with an elevation of 106 meters above sea level. Geleky has a number of active oil wells, abandoned drilling sites, and crude oil contaminated areas including human settlement and rice fields. In the investigation phytosociology and biochemical profiles of herbaceous communities in active and abandoned oil drilling sites of crude oil explored area was carried out with a special emphasis on HMs pollution. For comparison, a similar study was done in control sites where there were no evidences of oil exploration activities. After phytosociological investigation dominant herbs were selected for antioxidant enzyme profiles study to understand their defence mechanism against HMs associated stresses. The DPPH assay, reducing power assay and H<sub>2</sub>O<sub>2</sub> radical scavenging activities were the antioxidant enzymes which were studied. The results revealed that the plants growing near the heavy metals contaminated sites exhibit a higher level of reducing power, DPPH, and H<sub>2</sub>O<sub>2</sub> radical scavenging activities as compared to the plants of the control region. Thus, findings confirms the superior defence mechanism of the dominant herbs of the contaminated sites that include *Cyperus brevifolia*, *Parthenium hysterophorus*, *Polygonum hydropiper*, *Leucas aspera* and *Ageratum conyzoides* are suitable for use in phytoremediation practices.

**Keywords:** *crude oil; phytosociology; herbs; heavy metals; phytoremediation*



**Dhritashri Das, Hemen Deka**

*Recycling of harvested waste biomass of *Zingiber officinale* and *Curcuma longa* employing *Eisenia fetida**

India is the leading producer of both *Zingiber officinale* and *Curcuma longa*. As a result, the amounts of waste biomass generated after harvesting of these two crops are also huge. The unscientific disposal of waste causes environmental degradation. The present investigation deals with the study of vermicomposting potential of harvested waste biomass of *Zingiber officinale* and *Curcuma longa*. The *Eisenia fetida* was used as the experimental earthworm. The experiment was carried out in laboratory condition in pots by taking the mixture of waste biomass and cow dung in the ratios of 3:2 and 4:1. The efficiency of vermicomposting process was measured in terms of changes in physico-chemicals, macro and micro nutrients profiles, beneficial bacterial population, earthworm population and biomass. Besides, to understand the stability of the end products X ray diffraction (XRD) pattern, scanning electron microscope (SEM) imaging, ash contents, C/N ratios, enzymatic evaluation and humification index are also studied. The results revealed that there were significant changes in physico-chemicals, biological and nutrients profiles by end of the 60 days of experimental trials. Besides, there were enhancements in ash contents, reduction in C/N ratios indication the stabilization of the vermicomposting products. Further, increase in *Eisenia fetida* population and biomass indicates the suitability of the raw materials for vermicomposting.

**Keywords:** *recycling; waste biomass; eisenia fetid; C/N ratio; humification index*



**Dariusz Włóka**

### *Modern in situ bioremediation*

The in situ bioremediation method is based on the use of a microbial consortium as a tool for the pollutant's control. The biggest advantage of such a solution is low environmental invasiveness combined with relatively high effectiveness. It should be however noted that most techniques that rely on living organisms are burden with some technological drawbacks. First, point injection of bacterial or fungal strains has a limited area of influence, which can be additionally affected by the survival capacity of the applied microorganisms. Secondly, such a procedure may also be disrupted by the pollutant's migration effect or pure environmental conditions present in the treated area. Mentioned issues can be solved through the implementation of new modern materials and complex solutions such as immobilization.

The aim of this study is to present the concept of mobile microbiological deposits uses as a new, effective soil remediation bioagent type. The described solution consists of the preparation of a permanent microbiological bed in the form of a semi-permeable matrix. Such preparation after injection to soil can ensure continuous dosing of the active agent directly in the place where it can act most effectively.

**Keywords:** *bioremediation; soil pollution; bio agents; immobilization*

**Acknowledgments:** *Project funded by the GreenBack Ltd. R&D Department.*



## RAW MATERIALS AND WASTE

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**Magdalena Wdowin**

### *Development of CCP as an example of circular economy in the energy sector*

Coal combustion products (CCP) constituted remaining materials left after combustion of coal in conventional and/or advanced clean-coal technology combustors. These are among others: fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) by-products from advanced clean-coal technology combustors. According to ECOBA in the European Union approximately 40 million tonnes of CCPs are produced by year whereas only approximately 12 million tonnes are utilized. One of the promising products of CCP is fly ash due to specific chemical composition including silica and aluminium. Application of fly ash in hydrothermal reaction of porous materials synthesis enable to create circular economy in energy sector. Obtained products depend on structure type as well as after suitable modification can be applied in purification of exhaust gas as well as FGD wastewaters treatment. Besides them, porous materials can be used for safe green energy storage. The main aim of presented studies was to show circular economy on a real power plant case example. Fly ash constituted a substrate in reaction of porous materials synthesis among other zeolites type X, A as well as mesoporous materials i.e. MCM-41. Obtained materials after modification were used for capture of gaseous forms of mercury and carbon dioxide as well as FGD wastewater treatment (Hg and ammonia removal). Besides an innovative solution for hydrogen storage was developed. Results have shown that fly ash can be promising material to production of porous sorbents used for removal of environmental pollution and gas storage in energy sector.

**Keywords:** *fly ash; porous materials; mercury removal; carbon dioxide capture; hydrogen storage*

**Acknowledgments:** *Presented studies were realized within frame of three research projects financed by National Centre Research and Development i.e. FENCO-NET and LIDER programs as well as bilateral cooperation between Poland and South Africa.*

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**Radoslaw Pomykala**

*Management of anthropogenic, waste origin resources in the light of the implementation of the Circular Economy (CE) and the Green Deal (GD)*

The implementation of the Circular Economy (CE) and the Green Deal (GD) economy brings many new requirements and challenges for industries that generate significant amount of waste. This applies in particular to the mining industry, which produces half of all industrial waste in Poland. Declarations of climate neutrality will result in the abandonment of steam coal mining in the next 30 years, but it is a long time, and we are also extracting coking coal or copper ore. This guarantees that for many years to come we will be dealing with tens of millions of tons of mineral materials.

The paper discusses the key elements of the CE and GD, which to the greatest extent will shape the requirements and scope of activities in the field of waste rock, as well as areas transformed by mining activity, including heaps. The great challenge facing the industry is skilful shaping of waste management in such a way that it turns into the management of anthropogenic resources. The areas and directions of possible actions were indicated, including those concerning the reduction of the environmental impact, including emissions, the production of qualitative aggregate products, and the revitalization of transformed areas.

**Keywords:** *circular economy; CE; mining waste; anthropogenic raw materials; heaps; Green Deal; revitalization*

**Acknowledgments:** *Statutory research, AGH Krakow.*



**Krzysztof Starzyk**

*The use of natural volcanic materials found in Poland to reduce the carbon footprint of cement and concrete"*

The use of volcanic basalt tuffs as a binding material has been known for thousands of years, but in Poland it has never had any practical application for cement and concrete production. Tuff is a rock waste resulting from the exploitation of basalt deposits and because of its weak strength parameters it is mainly stored in heaps around mines as waste and occupies large areas of land. It is a kind of lightweight, compact, usually porous sedimentary rock consisting mainly of volcanic ash. Cement production accounts for 7% of global CO<sub>2</sub> emissions, and its main source is process CO<sub>2</sub> emissions from clinker production, and current technology makes it impossible to reduce them. One effective way is to reduce the share of clinker in cement by using various additives. Currently, it is fly ash and blast furnace slag added in different proportions in the cement production process. The abandonment of coal and steel in Poland limits their availability. Tuffs therefore become a valuable material in cement and concrete production. As a result of laboratory tests and production, the suitability of the volcanic tuff for cement production and as a grinded material for concrete production was confirmed. Tuff cements have already been certified in Poland and the process of introducing them to the market has begun. This is the first such cement in the history of the cement industry in Poland and the possibility of managing millions of tons of tuff waste. Cement with natural tuff in a mixture with other additives may have a carbon footprint lower by up to 50% in comparison with the currently produced ones. The use of volcanic tuffs in the production of cement and concrete will have a significant impact on the reduction of the carbon footprint in the industry's pursuit of net zero in 2050.

**Keywords:** *tuff; volcanic; cement; carbon; footprint*

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**Krzysztof Wójcik**

*Energy transition in Poland: sustainable management and efficient use of oil and gas resources*

The Polish Energy Policy states that prospection, exploration and production of oil and gas should be continued in Poland till at least 2040, although the production rate should stay at the same level. The demand of liquid fuels will be probably similar as in 2020. However, increasing demand of gas is expected due to the industrial development and gas use in households.

The geologists of the Polish Geological Institute – National Research Institute and Department of Geology and Geological Concessions of the Ministry of Climate and Environment indicate 24 most prospective areas for petroleum exploration in Poland. Four of them will be the subject to the next tender round for hydrocarbon concessions, planned in 2021. These are: Kartuzy, Siedlce W, Gryfice and Gorzów Wielkopolski S areas. Their main exploration targets are related to conventional and unconventional accumulations of oil and gas in the Cambrian sandstones, Ordovician and Silurian shales, Permian/Rotliegend sandstones and Permian/Main Dolomite carbonates.

The granting of the hydrocarbon concessions according to the tender procedure provides possibilities for government to control, intensify or limit of hydrocarbon exploration. However, the entities may also apply for concessions according to the open door procedure – for areas of their own individual interests. Both ways of granting concessions balance the Polish oil and gas market.

**Keywords:** *energy transition; crude oil; natural gas; hydrocarbon concessions; Polish Energy Policy*



***Adam Masłoń, Joanna Czarnota, Agnieszka Pękala, Marcin Chutkowski, Karolina Leś***

### *Fertilizer from municipal sewage sludge as an element of the circular economy*

The decisions of the European Commission of December 2015 in the field of the circular economy (CE) clearly show the need to reduce the amount of generated waste. This type of economy is an economic concept that assumes that raw materials, materials and products remain in the economy as long as possible, as well as, appropriate management of waste and minimizing its production. The assumptions of circular economy are aimed at, among others the need to use biodegradable waste for the production of new products, and according to the waste catalog (group no. 19), one of this type of waste is waste from wastewater treatment plants, including municipal sewage sludge. Municipal sewage sludge is a waste that is rich in organic compounds, nitrogen and phosphorus, the recycling of which, for example, in agriculture, through the production of new, full-value products, becomes an element of the circular economy in wastewater and sludge systems. The own activities undertaken in the scope of the assessment of the suitability of three different municipal sewage sludge for the production of a new product, taking into account an additional component in the mixture, i.e. diatomite, gave a positive effect and enabled the production of multi-component organic-mineral fertilizer. The physical and chemical properties of the sludge had a significant impact on the properties of the obtained final product, which in each variant was an environmentally friendly product and rich in components important from the point of fertilization application, which only confirms that the processing of municipal sewage sludge into organic-mineral fertilizers is an action, which complies with the principles of the circular economy.

***Keywords:*** *sewage sludge; fertilizer*



**Barbara Tora**

*Circular economy in raw materials management - good practices in the Polish zinc industry*

The article presents the implementation of the Circular Economy program in the Polish zinc and lead industry. ZGH "Bolesław" S.A. is the only Polish entrepreneurs mining zinc-lead ore. The share in the global production of zinc and lead amounts to approximately 1.3%, while in European production - 7%. ZGH extracts and processes zinc and lead ores from its own mine, ore enrichment plant and zinc smelters. The company produces: Electrolytic zinc, Zinc alloys, Wegal MOD, Zamak, Lead concentrate, Sulphuric acid, Casting zinc anodes, Rolled zinc anodes, Lead and zinc concentrate (bulk). ZGH produces zinc using the technologies of the electrolysis process and the Imperial Smelting Process and processes zinc-bearing waste in the Waelz process. The technologies used are safe for the natural environment. Production capacity reaches 150,000 tons of zinc per year. The company implements a comprehensive circular economy program: recovery of accompanying metals gallium and germanium, recycling of post-flotation waste deposited in a landfill , recovery of silver from the electrolysis process, rehabilitation of industrial sites with the use flotation waste, introduction of a new product - wegal alloy, work on the possibility of recovering metals from old heaps in the Bytom region. The company's strategy assumes systematic development of the company and continuous modernization of production processes, which ensure very good production parameters and guarantee the maintenance of a high position among global zinc producers. ZGH Boleslaw is a leading company in the implementation of the New European Green Deal.

**Keywords:** *circular economy; zinc; lead*



**Marzena Smol**

### *Strategies for the implementation of the Green Deal in the management of biogenic raw materials - phosphorus recovery*

The European Green Deal (EGD) presented on December 11, 2019 by the European Commission (EC) sets an ambitious action plan indicated as a new economic strategy of the European Union (EU). The main goal of the EGD is to transform the EU into a fair and prosperous society, living in a modern, resource-efficient and competitive economy with net-zero greenhouse gas emissions in 2050 and where economic growth is decoupled from the use of natural resources. From the beginning of 2020, new strategies for the EGD are systematically presented by the EC, including the “farm to fork” strategy, which was presented on May 20, 2020. The “farm to fork” strategy foresees the creation of more sustainable food systems. An important challenge within this strategy is to ensure access to food for the growing number of people. One of the possibilities for action in this area at the European level is to undertake further research works to ensure the raw material safety of biogenic resources, including in particular phosphorus (P), which is also evidenced as a critical raw material for the European economy (2014, 2017, 2020) and key raw material for the Polish economy (2015). The papers presents the importance of the recovery of P from waste generated in wastewater treatment plants (WWTPs). The main focus is paid to the sewage sludges ashes (SSA) generated in mono-incineration plants in Poland, in which P content reached 13%. The potential of P recovery from SSA was calculated based on the annual production of SSAs in Polish sewage sludge mono-incineration plants and average P content in SSAs. The recovery potential of 26,755.9 Mg of generated SSA in 2018 was equal to 2,674.1 Mg of P. The recommended pathways of SSAs management is their direction to chemical or thermochemical treatment, in which up to 95% of P can be recovered.

**Keywords:** *Green Deal; strategy; biogenic raw materials; recovery; phosphorus (P)*

**Acknowledgments:** *Research carried out under the Subvention of the Division of Biogenic Raw Materials at the Mineral and Energy Economy Research Institute, Polish Academy of Sciences.*



## INNOVATIVE MATERIALS FOR SUSTAINABLE FUTURE

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**Stefan Petters**

### *Distinguishing Greenwashing from real Green Deal Stories?*

Ecologic attitude has been rebranded quite a few times causing consumers' ambiguities impairing general acceptance in the subject matter. Starting out from World Wildlife Fund (WWF) foundation in 1961 through establishment of Greenpeace in 1971 the French Allez les Verde became a political movement in 1976 with several other countries to follow like e.g. Germany 1980 and Austria in 1984, "Green" was promoted as the "New Clean" ethics, style of living, etc., do-gooder image in general. Hostile perception of "better" as enemy of experienced "good", aggravated original idealists to anti-establishment citizens compromising their credibility in society who denied accepting them. Until the business world discovered the "Marketing Opportunity" to sell so called "Green Products" (concepts) for higher prices than such merchandize, or services would normally cost. Cynically arguing, anyone not prepared to pay more as a tribute to environment to be a bad member of society. As there was an obvious market for that, more and more businesses became greedy to grab it and soon everybody lost track of their procurements' compliance with any expected standards. Show me how a society handles its oddments, and I'll tell you how lavish they live! What most people don't understand is the fact that terminus of anything we throw "away" is atmosphere! Out of sight, out of mind, whether we get it burned or let it rot – any Carbon contained becomes CO<sub>2</sub> while water content either leaches all kinds of contamination into the terrestrial water cycle or is evaporated into the sky, forming clouds passed on to winds by thermic lift. According to IPCC both, CO<sub>2</sub> and Water vapor are Green House Gas [GHG] effectors. For 1t CO<sub>2</sub> one must know that it's 272.5 kg destroyed Carbon content are linearly replenished through 2.5 barrels crude oil equivalent fossil Carbon. Consequently, we all must be good people, paying double today, for what we could keep circular for half of today's total Life-Cycle Cost? Or are we just stultified by some extremely powerful networks of greed, exploiting Nature limitlessly to get a hold of people's money?

**Keywords:** *carbon; water; greenhouse gas; circularity; IPCC*

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**Rupak Kumar**

### *Morpholine: A Xenobiotic Pollutant Detection*

As per United States Environmental Protection Agency (US EPA) 2010, almost 4 billion pounds of toxic chemicals were released into the environment and increases annually at the rate of 16%. Morpholine and its derivatives (MAID) is one such chemical which is extensively used in myriad of industries like in rubber industry (vulcanization accelerator), plating industry (corrosion control), textile industry (lyocell process), synthesis of a large number of drugs, crop protection agents and as optical brighteners. Consequent to its wide range of applications and solubility, significant amount of this chemical is released via industrial effluents into environment. In the natural environment, its secondary amine functionality leads to nitrosation to form N-nitrosomorpholine, a well characterized carcinogen. The large-scale annual usage of morpholine (25,000 CA) and its potentially carcinogenic effects thus have environmental interest for its detection in natural as well as industrial effluents. The focus of research is to develop an analytical technique, which should be efficient, economical and rapidly deployable for estimating minute ranges of this analyte. Herein, a spectrophotometric method for quantification of morpholine was developed based on its reaction with 1,2-naphthoquinone sulfonate (NPQ/NQS). At room temperature itself morpholine undergoes a nucleophile substitution reaction in presence of sodium salt of 1,2-naphthoquinone-4sulphonic acid under alkaline condition to form a red/orange product, namely 4-(4morpholinyl)naphthalene-1,2-dione, which is detected at 480 nm. The reaction was completed in 20 minutes in dark. A linear relationship existed between the absorbance and the concentration of morpholine with a regression correlation coefficient of 0.99. This is a small volume, simple, sensitive, rapid, reliable and economical method for estimation of morpholine from 2 to 10 ppm and is amenable for automation to enable handling large number of samples at the same time.

**Keywords:** *industrial effluents; morpholine; carcinogen; spectrophotometric method; NPQ/NQS*



**Aleksander Czapla, Jakub Drewnowski**

*Composite as a material of the future in the era of sustainable development and Green Deal Implementation strategies*

Composite materials for some reasons become synonymous with something modern, desired in almost all areas of our everyday life, from simple everyday things, through sanitary facilities, pipelines to the construction of modern sewer network, their renovation, water supply, storage reservoirs, to complex structures - automotive, planes, space science. A significant increase in the interest of these materials is due to the properties of composites, their durability, strength, much lower energy consumption in the production process and they are also cheaper to transport. Composite materials are always ahead of steel, cast iron, concrete, etc. in terms of CO<sub>2</sub> emissions. Moreover, these specific materials have a long-life service cycle approximately 150 years or more, and are corrosion-free. Nowadays, further sustainable development depends on access to clean water, as well as a derivative of the availability of its resources and means of transport. Therefore, it's a great potential in using composite pipelines with their very low flow rate, which has a direct impact on the costs of drinking water pumping and irrigation systems. The paper reviews the available composite materials, their applications, and the potential for further development of their manufacturing technology towards nanocomposites and composites of natural origin, easy to biodegrade after their life service cycle, so called "green composite". The conclusions that arrived from this study is unequivocal, this type of composite materials need more research in the future as they fit very well with the philosophy of the sustainable economic development and Green Deal Implementation.

**Keywords:** *Green Deal implementation; composites; biocomposites; glass-reinforced plastic (GRP); reinforcement*



**Tomáš Bakalár**

### *Adsorption of Cr(VI), K(I) and NH<sub>4</sub>(I) Ions by Zeolites and Bentonites*

Chromium, ammonium, and potassium compounds are pollutants in the environment released mainly by industrial wastewater and they can negatively influence the quality of surface water. Zeolites and bentonites are commonly used adsorbents for removal of pollutant from water. In the study, the adsorbents were used in their natural form, without chemical modification for adsorption of Cr(VI), K(I) and NH<sub>4</sub>(I) from K<sub>2</sub>CrO<sub>4</sub>, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub> in a single compound system for each adsorbate separately. The Langmuir isotherm provided the best correlation for the adsorption onto the zeolites and bentonites. In the adsorption process of K<sub>2</sub>CrO<sub>4</sub>, the maximum adsorption capacities for removal of Cr(VI) by Z-M20, Z-M50, B-BL, and B-BR were 0.94±0.04, 0.82±0.03, 1.50±0.06, and 1.64±0.07 mg/g, respectively, and for removal of K(I) were 1.58±0.06, 1.54±0.06, 1.60±0.06, and 1.51±0.06 mg/g, respectively. In the adsorption process of K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, the maximum adsorption capacities for removal of Cr(VI) by Z-M20, Z-M50, B-BL, and B-BR were 2.71±0.11, 2.82±0.11, 4.21±0.17, and 4.21±0.18 mg/g, respectively, and for removal of K(I) were 1.98±0.08, 2.06±0.08, 1.01±0.04, and 0.93±0.04 mg/g, respectively. In the adsorption process of (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub>, the maximum adsorption capacities for removal of Cr(VI) by Z-M20, Z-M50, B-BL, and B-BR were 7.52±0.30, 7.45±0.30, 12.08±0.48, and 12.79±0.51 mg/g, respectively, and for removal of NH<sub>4</sub>(I) were 3.16±0.13, 3.35±0.13, 1.39±0.06, and 1.96±0.08 mg/g, respectively. The adsorption capacities of bentonite were higher than the adsorption capacities of zeolites from all the used adsorbates. The maximum sorption capacities of K(I) from K<sub>2</sub>CrO<sub>4</sub> were approximately the same. The maximum sorption capacities of K(I) from K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and NH<sub>4</sub>(I) from (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub> were higher for zeolites than for bentonites. The zeolites and bentonites were found to be suitable adsorbents for removal of Cr(VI) from aqueous solutions.

**Keywords:** chromium; ammonium; potassium; adsorption; zeolite; bentonite

**Acknowledgments:** This research was funded by Kultúrna a Edukačná Grantová Agentúra MŠVVaŠ SR, grant number 001UVLF-4/2020.



**Usha Kumari, Bhim Charan Meikap**

*Acid modified alumina: a simple, cheap and efficient solution to batch and continuous defluoridation*

The degrading water quality is one of major concern of many countries. The fluoride contaminated wastewater is one such problem. To get solution to this problem by adsorptive methodology, alumina was considered. The inefficiency of alumina to give better defluoridation result is tried to resolve by sulphuric acid activation. The enhanced defluoridation is reflected in batch reactor (63% to 97%) and the column ( $t_b$  from 3 to 353 min and  $t_e$  from 649 to 875 min). The improved result was supported by characterisation results of SEM/EDX, Raman Spectroscopy and BET ( $S_{BET}$  of 87.5  $m^2/g$ ) analysis. Another unique feature of the prepared adsorbent is its efficient working pH at 6.5 (close to 7) and filtrate water with pH in between 7 to 8. Besides, a very low amount (14 g) of  $H_2SO_4$  treated alumina gave efficient result in batch (97%) and column (74 %) for defluoridation of 40 mg/L of synthetic wastewater (1Ltr). The applicability of  $H_2SO_4$  treated alumina on industrial wastewater gave satisfactory result in batch (93%) and column (90%). The fluoride capture on the adsorbent followed the Freundlich isotherm model, pseudo second order kinetic model, Thomas model, Yan model, Yoon-Nelson model, Clark model, and BDST model. Another remarkable feature of the  $H_2SO_4$  treated alumina is its capabilities of regeneration and reusability. The NaOH (regenerating agent) caused the four times reapplication of same fixed amount of adsorbent. Besides, economic evaluation of adsorbent also favours its applicability in our day to day life as simple and efficient option for removal of fluoride.

**Keywords:** Fluoride removal; batch reactor; fixed bed adsorption column; alumina; acid activation; industrial wastewater treatment

**Acknowledgments:** I would like to acknowledge Indian Institute of Technologies Kharagpur, India, for help and support to carry out the present research work.

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**Singanan Malairajan**

*Removal of hexavalent chromium ions in synthetic wastewater using new alumina interfaced biocarbon*

Water is the most imperative asset for a wide range of life on this planet. The toxic heavy metals nonbiodegradable and released from the wastewater are very much harmful to the aquatic animals and to the environment. Chromium and its compounds are considered as the most dangerous pollutants and hazardous in nature. Trivalent chromium is much less toxic than the hexavalent form, which is recognized as a carcinogenic and mutagenic agent. Therefore, it is essential to remove it from wastewater before disposal. In the present study, a novel biocarbon was produced from the leaves of *Lawsonia inermis* plant. The surface characteristic of the biocarbon was enhanced by interfaced with inert alumina. Removal of Cr (VI) ions was carried out in synthetic wastewater to consider its application to the treatment of industrial wastewater. As a model study, a pilot scale adsorption experiments were conducted to study the effect of pH of the solution, adsorbent dose, contact time, initial metal ions concentration and temperature on adsorption of Cr (VI) ions from synthetic waste water. The results indicate that, the maximum removal of 98.70% of Cr (VI) ions (Co = 100 mg/L) was achieved at the optimum contact time of 180 min at the biocarbon dose rate of 3.0 g/100 mL. The effective removal of Cr (VI) ions is observed at the pH of 5.5. The present findings suggest that, the *Lawsonia inermis* plant leaves can be used to produce the best quality biocarbon for the removal of heavy metals from industrial wastewater.

**Keywords:** *Lawsonia inermis; alumina interface; biocarbon; hexavalent chromium; wastewater treatment*



**Patrycja Sobczak, Agata Rosińska**

## *Disinfection of treated wastewater using UV radiation in water reclamation process*

Providing people all over the world with drinking water of suitable quality is crucial. Therefore, water quality monitoring is a very important matter. However it is strictly associated with the problem of its insufficiency as the growing pollution and poor management make it harder to fulfil the conditions contained in law regulations concerning water quality. Latest regulations proposed by the European Commission provide encouragement to develop the ways of water reclamation, e.g. from treated wastewater from municipal wastewater treatment plants and reuse, e.g. in agriculture. Although it is essential that the water obtained in the process complies with the microbiological and chemical requirements regulated by law. Unfortunately it is unavailable to reach it with conventional wastewater treatment processes. Especially when it comes to removing emerging pollutants such as polycyclic aromatic hydrocarbons or some pharmaceuticals. Obtaining the wastewater purified to a degree as it is possible to reuse it as reclaimed water would be a perfect solution and it seems like the disinfection process is the answer to that. Choosing the method that would allow achieving the desired effect is essential. UV radiation combined with other disinfection methods may be effective to dispose of pathogens in water. It may also provide effective reduction of trace organic chemical compounds. However, it is important that wastewater is properly treated before the disinfection for the process to be effective. This paper presents an overview on the matter of disinfection of treated wastewater using UV radiation also in order to obtain reclaimed water.

**Keywords:** *reclaimed water; wastewater disinfection; UV radiation*



**Anastasiia Sholokhova, Gintaras Denafas**

### *Microplastics in organic outputs from MBT*

Mechanical Biological Treatment (MBT) as a source of microplastics began to be considered only recently. However, the first experimental data and modelling of the microplastic concentration in organic outputs from MBT showed that waste treatment can even be the second-largest source of microplastics. Part of the amount of microplastic may come with waste, but most of the microplastics in the MBT plants are formed during waste processing due to the shredding of large waste plastics. Due to their size, microplastics fall into the organic fraction after separation and end up in the organic outputs. Some MBT plants also treat separately collected food waste and have composting sites for green waste. However, even the compost from green or food waste can contain a significant amount of microplastic due to the accidentally included packaging materials or disposal bags.

This work aimed to investigate the formation and concentration of microplastics in different organic output from the MBT. For analysis, samples of organic output after processing mixed municipal waste, as well as green and food compost were taken. Extraction of microplastics included the steps of sieving, removal of organic matter by Fenton's reagent, and separation from inorganic components by density separation. The particles extracted and concentrated on the filter were stained with Nile Red and examined under a fluorescent microscope. To count the number and measure the size of microplastics, the software ImageJ was used.

**Keywords:** *microplastics; MBT; compost; Nile Red*

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***Justyna Wrzosek-Truszkowska<sup>1</sup>, Barbara Gworek<sup>1</sup>, Svetlana Mintova<sup>2</sup>***

***The impact of zeolites on the inactivation of selected plant product protections  
in aquatic environment***

The purpose of the research was to assess the effectiveness and selectivity of aluminosilicates - natural and synthetic zeolites – for the removal of selected plant protection agents from the aquatic environments. The research was based on laboratory experiments (on biological and chemical indicators). The structure of zeolites – containing chambers and channels of different size – determines their diversified physical and chemical properties, including their specific surface area, sorption capacity and ion exchange properties. For this reason it will be necessary to select appropriate zeolites to match the pendimethalin/glyphosate present in the aquatic environment in order to inactivate it. Natural and synthetic zeolites demonstrated selective sorption of pendimethalin and glyphosate. Moreover, a natural zeolite-bearing rock containing heulandite and clinoptilolite was found to be most effective in inactivating pendimethalin and glyphosate in the aquatic environments. The addition of a natural zeolite-bearing rock to a water emulsion of the pesticide reduced the toxicity of pendimethaline to selected crop plant species. The highest statistically significant impact of a natural zeolite-bearing rock on the reduction of phytotoxicity of pendimethalin was found for cereals (barley, rye) and the lowest one was noted for charlock. Granulation significantly affected the effectiveness of the binding of these active substances by a natural zeolite-bearing rock in the aquatic environment.

***Keywords:*** *heulandite; clinoptilolite; NaY, 4A; pendimethalin; glyphosate*

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## CRITICAL RAW MATERIALS IN GREEN DEAL – PHOSPHORUS CASE OF STUDY

Session of InPhos project (EIT Raw Materials)

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This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation





**Magdalena Svanström**

## *Does Sweden have enough phosphorus, and what are the environmental impacts of phosphorus recovery from sewage sludge?*

The presentation highlights some findings from various research projects done at Chalmers University of Technology in recent years and summarises some of the input that was provided to the InPhos project (EIT Raw Materials).

Biomass production relies on functioning cycles of e.g. carbon, nitrogen and phosphorus. For phosphorus, local cycles should be possible, and desirable also from the perspective of security of supply, especially for countries without their own phosphorus mining such as Sweden. Based on a material flow balance for phosphorus in Sweden for the year of 2017, it was concluded that local cycles of phosphorus in Sweden could be possible for forestry by closing the loops for currently underutilised biobased outputs, but for agriculture, this would not be enough to remove the dependency on imported mineral fertilisers. However, if phosphorus in iron ore mining waste would be recovered, Sweden could become a net exporter of phosphorus.

Cycles of carbon, nitrogen and phosphorus are all necessary for biomass productivity, but for all of these, severe environmental problems can also arise if cycling efforts are not performed properly. Based on a life cycle assessment for the Swedish water sector in 2015-2016 it could be seen that various efforts to return phosphorus in sewage sludge to agricultural land all had their most important environmental impacts related to the carbon and nitrogen in the sludge itself. It is therefore important that emissions of ammonia, methane, nitrous oxide and nitrate are kept low during or after treatment of the sludge. Efforts to cycle phosphorus should thus consider what happens also to carbon and nitrogen and make sure that all these elements become resources rather than environmental problems.

The presentation also concluded that even after many years of method development in life cycle assessment in the group, some aspects remain challenging to assess for the context of sewage sludge use in agriculture. Considerable improvements have nevertheless been done with regard to assessing impacts related to toxicity, pathogen risk and odours, as well as benefits related to soil organic carbon.

**Keywords:** *phosphorus; life cycle assessment (LCA); sewage sludge*

**Acknowledgments:** *This work was funded by the project “Sustainable Management of Phosphorus in Baltic countries” (InPhos), No. 17022 (2018-2020) that is financed by the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation. Web-page: [inphos.info](http://inphos.info).*

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**Jessica Rossi, Augusto Bianchini**

*Sustainable use of phosphorus raw materials on the example  
of Italian companies*

Although intensive efforts have been focused on a more sustainable use of phosphorus (P) in the last two decades, the full-scale implementation of P recovery technologies is not widespread in the industrial sector. Their diffusion is limited by lack of high-resolution and integrated analyses about the potential, benefits and risks of industrial innovation in this field, and the quantification of business, economic, environmental and social impacts at firm level. To cover this gap, the University of Bologna developed an industry-oriented methodology to deliver quantitative information, necessary to companies to explore their potential pathways about P recovery. The methodology, developed through the knowledge gained in two EU projects, InPhos (EIT Raw Materials) and Prosumer (EIT Climate-KIC), consists of four main steps: (i) identification of business interests and constraints; (ii) assessment of P flows in the company boundaries; (iii) cost assessment; and (iv) sustainability assessment through relevant Key Performance Indicators. The methodology was applied to an Italian food company, highlighting that only less than 50% of the P contained in raw materials remains in the final products and that the implementation of a P removal technology allows the compliance of legislative limits. Nevertheless, the economic feasibility is not ensured, confirming literature results. Consequently, suitable and tailored policies and financial tools must be defined to support the diffusion of P recovery at industrial level. The quantitative information provided by the methodology are therefore useful for policy makers and financial bodies to respond to needs and specialization of companies in their territories.

**Keywords:** *phosphorus management; material flow analysis; economic feasibility; waste streams; impact assessment*

**Acknowledgments:** *The authors acknowledge the EIT RawMaterials and the EIT Climate-KIC – bodies of the European Union, which funded respectively the projects InPhos (no. 17022, 2018–2020) and Prosumer (no. 200103, 2020).*

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**Jolita Kruopienė**

## *Examples of management of phosphorus resources in Lithuania in the context of circular economy*

The main objective of the study was to analyse the circularity of phosphorus management in Lithuania by looking at the existing phosphorus management examples in the country.

An important user of primary phosphorus is a company producing mineral phosphorus fertilizers. The raw material is supplied mainly from Russia, South Africa. Most of the production, about 98%, is exported. So for now, we have a linear model: phosphorus comes to and from the country.

Lithuania imports mineral fertilizers to meet the needs of its own agriculture. Phosphorus from secondary sources is also used, although so far in smaller quantities than primary phosphorus: from animal manure, sewage sludge, compost. Wastewater treatment plants (WWTPs) produce more than 40,000 Mg of sludge per year, of which 48.3% were used for fertilization and reclamation, 38.7% for compost in 2017 (according to the Environmental Protection Agency), this way closing the cycles of phosphorus. Phosphorus recovery technologies are not yet implemented. In 2017 for the first time, 0.3% of the sludge was incinerated with municipal waste and in cement kiln. The first drying-(mono)incineration plant is being built in Utena, where it would already be possible to recover phosphorus from incineration ash.

There are interesting examples of circular economy models (CE) in the country, such as EU LIFE project NutriBiomass4LIFE. It aims to create and demonstrate full scale self-sustainable closed loop CE model for large cities' nutrient (including P) rich waste - municipal WWTP sludge and biomass boiler ashes – recycling into renewable energy for city's needs via biomass plantation filter.

To summarize:

- Lithuania is economically and socially vulnerable with regard to availability of primary P resources (fertilizer production);
- It is dependent on P fertilizer import for its agriculture (food import-export profiles with big export of cereals hardly allow self-sufficiency from secondary sources);
- Attention should be paid to agricultural practices in order to minimize P losses;
- Attention needed to sewage sludge management.

**Keywords:** *wastewater management; phosphorus; recovery; circular economy; Lithuania*

**Acknowledgments:** *This work was funded by the project “Sustainable Management of Phosphorus in Baltic countries” (InPhos), No. 17022 (2018-2020) that is financed by the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation. Web-page: [inphos.info](http://inphos.info).*

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**Rūta Ozola-Davidāne, Māris Kļaviņš**

*From research to management of phosphorus flows and implementation of circular economy concepts: case study in Latvia*

In Latvia, like in other European Union countries, there are no economically significant deposits of phosphate rock and demand for phosphorus-bearing materials is satisfied entirely by imports. Thus, phosphorus (P) recovery from secondary sources such as wastewater, sewage sludge and sludge ash is an important step towards the transition from a linear to a circular economy model. Circular Economy Strategy for Latvia, which is in the development stage, includes the importance of new recycling technologies, improved waste processing, and reduction, and it prioritizes the closed material cycle. There is an overview of European Union actions in the appendix of the Strategy, mentioning the importance of processing critical raw materials and reusing of sewage sludge. However, no specific measures are determined to recover phosphorus from wastewater flow. Treated sewage sludge is mainly placed in temporary storage units, or is used in agricultural applications, composting, greening, and recultivation of degraded areas. Nevertheless, there are examples of good practices in municipal sector. In the wastewater treatment plant (WWTP) “Sloka” (Latvia), sludge from the wastewater treatment process is dried by gas and steam flow and then gasified in the microwave-assisted gasification process. Thus, reducing temporary stored or landfilled sludge by 70%, with the potential to use it for phosphorus recovery. By increasing the recovery of phosphorus from wastewater and reusing it as a fertilizer in agriculture, it is possible to reduce dependency on supplier countries, avoid depletion of phosphorus, protect the environment from eutrophication and enhance transformation towards the circular economy model.

**Keywords:** *wastewater management; phosphorus; recovery; circular economy; Latvia*

**Acknowledgments:** *This work was funded by the project “Sustainable Management of Phosphorus in Baltic countries” (InPhos), No. 17022 (2018-2020) that is financed by the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation. Web-page: [inphos.info](http://inphos.info).*

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**Marzena Smol**

## *Sustainable and circular phosphorus management in the Baltic region – summary of the InPhos project*

Project “InPhos - Sustainable Management of Phosphorus in Baltic countries” has been implemented by the Knowledge Triangle Consortium from Poland, Germany, Sweden, Lithuania, Latvia, Estonia, Finland and Italy in 2018-2020. The main objective of the project was to develop of sustainable and circular management strategy for phosphorus (P) in the Baltic Sea region. Strategic InPhos objectives included identification of best management practices of sustainable phosphorus usage in developed countries (as Germany, Sweden, Finland, Denmark); identification of the recovery potential for phosphorus in the Baltic region; transfer of knowledge and design of solutions for the sustainable use of phosphorus; promotion of the closing of the phosphorus cycle by various education and promotion events (over 750 participants in Wider Society Learning events have been educated; competitions on circular economy and P have been organised for over 130 Participants) and building of “Phosphorus Responsible Society”. The main theme of the project was design of products and services for the circular economy. The project was successfully implemented in the period of time 2018-2020, thanks to support of the EIT Raw Materials.

**Keywords:** *circular economy (CE); phosphorus (P); sustainable management; raw materials*

**Acknowledgments:** *This work was funded by the project “Sustainable Management of Phosphorus in Baltic countries” (InPhos), No. 17022 (2018-2020) that is financed by the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation. Web-page: [inphos.info](http://inphos.info).*



## GREEN STRATEGIES FOR WASTE AND ENERGY

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***Paramita Chakravarty, Hemen Deka***

***A study on crude oil contaminated soils health of Lakowa oil field, Assam***

Soil pollution by crude oil is of growing concern all over the world. It is considered one of the serious environmental threat around the globe. In the present study, the effects of crude oil pollution on agricultural soil were studied terms of soil physico-chemical conditions, beneficial microbial populations, enzyme profile and total petroleum hydrocarbons (TPHs) contents. The group gathering station (GGS) where crude oil is stored before sending it to refineries were considered as source of polluter. The soil samplings were done at various distances from the polluter. The results showed lower pH, conductivity, Water Holding Capacity (WHC), moisture contents, total potassium and higher value of total organic carbon (TOC), total kjeldhal nitrogen (TKN) and available phosphorous (AP) in the contaminated sites of GGS-1, GGS-2, GGS-3, GGS4, GGS-7, GGS-8 and pipeline leakage of Lakowa oil fieldwhile compared with control soil. The results also revealed significant increase in soil dehydrogenase, urease, alkaline phosphatase, catalase, and amylase activities in the crude oil contaminated soils as against the control soil samples. There was a significant increase in beneficial microbial populations that includes nitrogen fixing, phosphate and potassium solubilizing bacterial population. The TPHs contents were found to be maximum in case of the soil samples of nearby distance (5m) from the polluter of GGS-3 whereas it was minimum in soil samples of GGS-2 at 100 m distance.

***Keywords:*** soil pollution; crude oil; physico-chemical; soil enzyme; Total Petroleum Hydrocarbons

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**Renata Tomczak-Wandzel, Maria Magdalena Estevez Rego**

*Fish Sludge Co-digestion - The Way to Maximize Utilization of Western Norway's Waste Resources*

At western Norway, the availability of waste resources coming from the fisheries, aquaculture and fish processing sectors, is relevant for biogas production and nutrients recovery. New on-land based plants are planned in the region, and due to stricter regulations, the trend is towards new closed-systems plants (RAS: Recirculation Aquaculture Systems), which will provide higher amounts of sludge as well which will require proper and sustainable treatment and management. Implementing biogas plants within the aquaculture farms is not an economically feasible option for the sector but an interesting alternative is to treat the sludge and waste at already existing biogas plants that have such capacity to co-digest them with other substrate fractions, as sewage sludge. This will contribute to higher biogas potentials and higher recirculation of nutrients. Addition of 30 % in VS of fish sludge gave an average increase of 35 % methane (mesophilic conditions). In thermophilic conditions, addition of 30 % in VS of fish sludge caused inhibition problems due to high ammonia concentration, that reached 1970 mg NH<sub>4</sub>-N/L. Additions fish sludge up to 20 % gave a stable process. The importance of conducting specific co-digestion evaluations before accepting a new waste fraction into an established biogas plant is emphasized. Due to concentration of Zn, digestate generated categorized as quality class III according the Norwegian regulation. This may limit the possibility of using fish-related waste biomass as co-substrate for biogas production if the aim of the plant owner also includes using the digestate as a fertilizer.

**Keywords:** *aquaculture; fish sludge; co-digestion; biogas; fertilizer*



**Mariusz Ruszel, Przemysław Ogarek, Adam Masłoń**

*Analysis of biogas potential from sewage sludge digestion in terms of diversification in the natural gas production structure in Poland*

Produced in relatively large quantities, renewable biogas can complement, constitute domestic production of natural gas, a transitional fuel in the process of achieving the objectives of the Green Deal - under which the European energy sector is to become a net zero-carbon energy sector by 2050. The additional volume of green gas fuel will contribute to the diversification of the production structure of this raw material and will also strengthen the energy security of the state. The intensive development of construction or expansion of sewage networks and municipal sewage treatment plants observed in Poland in recent years leads to the formation of significant amounts of municipal sewage sludge. Currently, at about 2,500 sewage treatment plants, only nearly 140 sewage treatment plants are equipped with installations for full fermentation of sewage sludge. This means that only 6% of the sewage treatment plants operating in Poland produce biogas, which can be used for energy purposes. The total volume of digesters in all sewage treatment plants is estimated at 800,000-900,000 m<sup>3</sup>. Nevertheless, the energy potential of biogas can be increased by using new technologies that enable intensification of production from biogas (e.g. thermal hydrolysis, co-digestion). Biogas produced in wastewater treatment plants can also fit in with the main objectives of the EU's hydrogen strategy, enabling the production of so-called green hydrogen, e.g. in the reforming process. The aim of this work is to analyze the energy potential of biogas generated in the processes of methane fermentation of sewage sludge in the context of implementation of the European energy and climate policy, while maintaining the highest possible level of state energy security. The following research questions were asked. What are the barriers to biogas development from sewage sludge digestion in Poland? To what extent can biogas support the energy transformation process in Poland? The research hypothesis was posed that the production of biogas from sewage sludge digestion will contribute to the increase of energy security through the development of distributed generation and reduction of natural gas transmission losses in Poland.

**Keywords:** *biogas; methane fermentation; natural gas*

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**Māris Kļaviņš, Dmitrijs Porsnovs, Raivo Damkevics**

*Development of carbon capture technologies as a crucial tool to achieve carbon neutrality aims*

Climate change problems are becoming a priority issue worldwide and requiring urgent actions to reduce emissions of greenhouse gasses (GHG). However reduction of GHG emissions alone cannot help to reach climate neutrality aims as it is stated in EU Green Deal. To reach climate neutrality aims at the same time keeping up welfare level of society, it would be important to capture carbon emitted during different technological processes, at first as a result of combustion or incineration technologies. Thus major efforts should be put on development and implementation of carbon capture and storage (CCS) technologies. There are several approaches suggested and already implemented at pilot scale. But further testing of different approaches still is actual. One of sectors, where CCS technology application would be essential is waste processing technologies. Aim of our research is to study possibilities to use CCS for small scale gasification of waste biomass and municipal solid waste fraction – solid recovered fuel. We have developed facility to transform SRF to syngas and waste char. Waste char have prospects of application as a fuel as well as sorbent for different applications. The application of pre-combustion carbon capture to waste gasification syngas can provide opportunities to reduce emissions of CO<sub>2</sub>. The study of sorbents, prospective for CCS application to waste processing is on a way.

**Keywords:** *carbon capture and storage; gasification; solid recovered fuel*

**Acknowledgments:** *Research is supported by ERDF project Nr.1.1.1.1/19/A/013 “Innovation of the waste-to-energy concept for the low-carbon economy: Development of novel carbon capture technology for thermochemical processing of municipal solid waste (Carbon Capture and Storage from Waste - CCSW)”.*

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***Aleksandra Przyłucka, Marcin Rywotycki***

### *Development directions of photovoltaic panels recycling*

The lifespan of current photovoltaic modules guaranteed by manufacturers is around 25-30 years. In practice, many users decide to exchange their PV installations earlier. The purpose of this is to obtain more energy from constantly improved technologically photovoltaic cells. Based on the forecasts and currently used installations, it is estimated that by 2050 there will be 60 to 78 million tonnes of waste PV. Recycling of decommissioned components of photovoltaics installations minimizes the waste of environmental and economic resources.

Crystalline silicon remains the dominant material for production of photovoltaic cells worldwide. Its share accounts for approximately 85-90% of the global PV market. Recycling begins with removing the aluminum frames and wiring the panels. The partially dismantled panel is rich in glass, silicon, copper, silver and plastic. The next step in the process can be carried out in two ways. The first way is to grind the obtained materials and separate them from each other using screens, densitometric tables and optical separators. This is how over 90% of valuable materials can be recovered. Alternatively, remelting parts are separated. Under the high temperature, plastic is removed, leaving the silicone cells resistant to heat that can be reused.

The aim of the work is to analyze the currently used technologies and research progress in the field of recovery and recycling of materials from silicon waste from the PV industry.

***Keywords:*** *photovoltaic panels; recycling; silicon recovery*



**Meryem Taoufik, Ahmed Fekri**

### *Land Suitability Analysis for Solar Farms Exploitation Using GIS and Analytic Hierarchy Process (AHP) - A Case Study of Morocco*

Considering the geographical location and climatic conditions of Morocco, solar energy can satisfy the country's energy demand while reducing the power cost. However, determining socially suitable and economically viable locations for solar projects is a complex process that involves a number of technical, socio-economic and environmental factors. The aim of this research is to find the most suitable locations for solar farm development in Morocco using a GIS-based multi-criteria decision method. Thirteen site selection criteria were considered and the analytical hierarchy process (AHP) was used as a multi-criteria decision analysis tool to get factors' weights and make the optimum site selection. Obtained results show a great potential for solar energy development in Morocco, represented by the availability of 90% of areas. In fact, the resulting map was classified into 4 different classes, namely: Very suitable, Suitable, Less Suitable and Unsuitable, which 9%, 81%, 2% and 8% are respectively the percentages of their area occupation. The obtained map was then compared to the existing solar farms, and show that most of the existing projects are located within or adjacent to areas classified as suitable. These findings show that the proposed model can be a valuable tool for evaluating and assessing the land use potential for solar farm in areas with similar geographic conditions.

**Keywords:** *Geographic Information Systems; Multi-criteria Evaluation; Solar energy; Photovoltaic potential; Site Suitability;*

**Acknowledgments:** *The authors want to acknowledge the many data originators whose work and input formed the basis of this research.*

*Map data copyrighted OpenStreetMap contributors and available from <https://www.openstreetmap.org>.*

*The protected area data layer used in this research is a product of the World Database on Protected Areas (WDPA): UNEP-WCMC (2020). Protected areas map of the world, September 2020 Available at: [www.protectedplanet.net](http://www.protectedplanet.net)*

*Data is obtained from the Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU) in partnership with the Global Horizontal Irradiation data are obtained from the Global Solar Atlas 2.0, a free, web-based application is developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilizing Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: <https://globalsolaratlas.info>.*

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**Sowjanya Sree Kanregula <sup>1</sup>, Klaus-J. Appenroth<sup>2</sup>**

### *Duckweed as potential raw material for biofuel production*

Duckweeds are aquatic flowering plants with lentic habitats belonging to the plant family Lemnaceae. These include the smallest and the fastest growing angiosperms. One of the interesting features of duckweeds is that these plants can accumulate either high amounts of starch or protein depending on the cultivation and growth conditions. In the present study focus was to investigate the starch accumulation capacity of different species of duckweeds under different cultivation conditions. The effect of nutrient limitation i.e., low content of phosphate, nitrate and sulphate in the growth medium and that of salinity of the nutrient medium on the starch accumulation capacity of different species of duckweeds was studied. Also, the duration and the method of cultivation had an effect on the amount of starch accumulated by these plants. It was found that under these stressed conditions some of the duckweed species could accumulate up to 40 % starch per dry weight. The advantage of the use of such starch rich duckweed biomass is that the starch is accumulated in the entire plant body and not just in a specific organ like in other biofuel crops. And, the entire plant material can be harvested from the cultivation site and this starch-rich biomass can be used as raw material and resource for biofuel production.

**Keywords:** *duckweed; starch accumulation; biofuel resource; nutrient limitation; salinity*

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**Klaus-J. Appenroth<sup>1</sup>, Sowjanya Sree Kanregula<sup>2</sup>**

### *Duckweeds for green deal implementation*

Based on the very high growth rates, duckweed can be a potential source of production of high amount of biomass. Under optimal growth conditions, duckweeds may contain ca. 30 % protein per dry weight and ca. 10 % starch providing an ideal material for human nutrition. The amino acid spectrum of the protein fulfils all requirements of the World Health Organisation. The fat content is low (ca. 5 %) but two third of the fatty acids are polyunsaturated ones. Moreover, the ratio between omega-6 and omega-3 fatty acids, which should be smaller than 5 for human nutrition, is less than 1 in all duckweed species. The plant material is rich in carotenoids and tocopherols. Further, the content of minerals can be adjusted to the requirements in a wide range depending on the cultivation medium used.

On the other hand, because of the high growth rates, duckweeds can be used either for cleaning wastewater (bioremediation) or for monitoring the presence of possible toxic compounds (Biomonitoring) with respect to the presence of heavy metals or xenobiotics. Also eutrophic surface water can be cleaned using duckweed.

After the complete genomic sequencing of quite a number of duckweed species, also robust methods for genetic transformation, like CRISPR-Cas, are available to produce e.g. vaccines.

**Keywords:** *biomass; duckweed; human nutrition; feed; Lemnaceae*

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## ACTIONS FOR CLIMATE AND CIRCULAR ECONOMY

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***Małgorzata Roge-Wiśniewska***

### *Challenges of climate change for water management*

Currently, mankind is facing a number of challenges, such as counteracting climate change and adapting to it. Global threats to the environment must meet a quick and efficient response at all levels of our civilization - from actions on the global scale, through regional to local ones. One of the key challenges is water management. We must prepare for more frequent and longer-lasting droughts as well as for an increase in rainfall intensity that can even result in geomorphological changes. Effective water management should focus on retention and utilisation of rainwater, on cultivating plant species that are resistant to droughts and use less water, on reducing evaporation from the soil surface, and on effective irrigation. The aim of paper is to present solutions that can be used not only in urban or agricultural areas.

***Keywords:*** *climate change; water management; solutions*



***Izabela Kielb-Sotkiewicz***

***The use of "Google Trends" tool in the analysis of growing interest in the subject of waste segregation on an example of Poland and Italy***

A characteristic feature of our times is the general and unhampered access to information. The historical stage we live in is distinguished by both the quantitative and qualitative explosion of data - information, in almost every area of life. We use this data in everyday functioning as well as in marketing and science. In addition to traditional trends (e.g. peer-reviewed publications, official databases such as the Central Statistical Office of Poland), information - generally considered reliable - is also obtained from internet search engines. Only in recent years access to the Internet in households has increased from 75.8% in 2015 to 86.7% in 2019. It is the increase in availability of the Internet in society and its use to obtain information that naturally creates large data sets, i.e. Big Data.

In recent years the problem of "littering the world" and its consequences have been talked about more and more often and louder. Especially about the effects on the natural environment, and thus on ourselves. In response to the dangerous consequences of improper management of municipal waste, the legislator has prepared a number of tools aimed at improving the condition of the natural environment, including imposing on the citizen the obligation to segregate waste.

The aim of this article is to analyse the trend related to the topic of waste segregation using the Google Trends tool on an example of Poland and Italy, and then an attempt to draw conclusions to what extent the "Internet search trend" is reflected in reality and what, in a given country, translates into increased interest of Internet users in given subject. In the content of the article was made an analyses of applicable legal acts relating to waste management and describes the socio-political conditions for Poland and Italy, respectively.

***Keywords:*** *waste segregation; Google Trends; Big Data*



***Urszula Litwin, Przemysław Baster***

***Polish rural designing system used for the implementation of the ideas of green deal and sustainability – comparison of landscape and agricultural areas planning, on the example of Strzelce Wielkie and Kamionka Wielka***

Issues related to the system of protection and planning of rural landscape undoubtedly differ from the topics concerning the transformation of agricultural areas and their proper management. These are separate specialties, studied by researchers representing different disciplines, although they often relate to the same village and they are aimed to implement the ideas of green deal and sustainability. The experience from independent research projects in Kamionka Wielka (agricultural areas) and Strzelce Wielkie (landscape of rural and green areas) confirm the variety of individual issues and topics discussed. Nevertheless, presented in the article comparison of these projects also point to similar methods of analysis and planning applied at individual stages of a Polish four-stage designing system: ‘resources – valorisation – guidelines – design’. Research results indicate that this system, almost identical to the European ones, used for half a century in landscape architecture, can be also useful for planning agricultural areas. This will allow local authorities to realize the idea of green deal – draw up a more perfect development project for the whole village and simultaneously standardize project documentation. Designers and scientists – representing various fields of science – will be able to achieve better cooperation and fitting spatial planning solutions; this way, interdisciplinary activities and final design will implement the idea of sustainability.

***Keywords:*** *sustainability; interdisciplinary rural planning; designing system; streams; millruns*



**Kamil Olzacki**

### *Sustainable Urban Mobility Planning and its impact on preventive environmental protection*

The transport sector belongs to the sectors of global economy that have the biggest impact on public health and the environment. Recent studies have even shown that it is the only one economic sector with a significant increase on harmful greenhouse emissions in the European Union (EU-28). To prevent further environmental pollution, the EU's "European Green Deal" set a difficult task for the member states - to reduce emissions in the transport sector by as much as 90% by 2050.

A sizable portion of greenhouse emissions in the transport sector results from the urban mobility. Exploitation of different modes of transport within the functional urban areas adversely affects the local environment as well as the public health. It must be said that a significant reduction of greenhouse emissions in the whole transport sector is not possible without reconsidering and its impact on preventive environmental protection and reinventing urban mobility policies from the bottom up, especially in EU's metropolises.

Local authorities are constantly looking for innovative solutions that would help counteract further greenhouse pollutions on the urban level. The Sustainable Urban Mobility Planning (SUMP) – an innovative mobility planning strategy based on the principle of sustainable development – has recently proved to be the right solution to do it.

The paper presents the analysis of the current environmental situation of the urban mobility and the concept of the SUMP and its importance for preventive environmental protection. Furthermore, the environmental effects that may be associated with the implementation of the SUMP strategy are discussed.

**Keywords:** *transport; mobility; preventive environmental protection; Sustainable Urban Mobility Plan; sustainable development principles; reducing greenhouse emissions*



**Marcin M. Rychlak**

*Extending the support mechanisms for green energy investments by  
internalizing positive externalities on the instance of small hydropower  
in Poland*

There is no doubt that the flagship of the European Green Deal development strategy is the climate neutrality. This alone makes the claim about the necessity of fundamental change of the obtaining electricity technology by the Polish economy undeniable. Such transformation is to be made by the means of renewable energy sources - RES (meeting only the non-fossilization condition in the Polish nomenclature). Therefore, the selection of the specific RES technology aiming to transform the energy industry in Poland, shifts from the condition of compliance with the non-fossilization principle, to further conditions related to financial and technical part of the transformation. Hereby, the value of the environmental factor is determined in the construction of „green” support mechanisms, in which each RES is treated equally. Indeed, there are large differences between renewable energy technologies, within which it is possible not only to stop the emergence of negative environmental externalities, but also to create positive externalities. This situation may occur in the case of small hydropower in Poland where the revitalized installations may generate positive externalities. Therefore, the legitimacy of introducing an adjustment optimizing the small hydropower (SHP) support mechanisms should be considered, as they lead to the synergy of actions necessary to implement the „green deal”. The basis of the support mechanism should remain the energy component and contrarily the newly added part to the above mechanism should constitute cumulative and valued positive effects in the field of: improvement of channel retention, revitalization of water dams, revitalization of historical buildings or the creation of tourist infrastructure.

**Keywords:** *external effects; ecosystem services; renewable energy; hydropower; renewable energy sources - RES support mechanisms*



**Adrian Pietrzyk**

*Ecology as an element of the CSR strategy in the functioning of football clubs in Poland and in the world*

Football has become a business, as evidenced by the income of football clubs around the world, as well as the salaries of players, and proceeds from sponsors. However, as enterprises that play a huge social role in the functioning of the local community, they should base their activities on educating the community and promoting positive habits - also related to environmental protection and sustainable development. The aim of the work is to present good practices that are used by football clubs in Poland and around the world for environmental protection, the use of renewable energy sources, and recycling. One research question was asked in the paper - what practices are used by football clubs to promote environmental protection among the society and what are the consequences of those activities. A case study was presented in the work, which showed a number of positive practices and their effects that affect other goals of sports enterprises (including marketing, financial image goals). Research confirmed that appropriate management of the company's resources in an ecological way contributes to the growth of its popularity and improves its image.

**Keywords:** *corporate social responsibility (CSR); strategy; football clubs*



**Zuzanna Borowska, Magdalena Szczepanek**

### *Should you be a climate optimist?*

Maybe there's still some hope...  
...so should you be a climate optimist?

What is the role of the young generation in shaping the future of climate action and climate policy-making? How are young people leading local, national and global movements? How does their engagement change over time, where do they find energy, motivation, ideas and hope?

Our presentation tried to offer an answer to all these questions by telling a story of the youth climate movement in Poland, with its various members, organizations and projects, stories of success and lessons learned. We gave some special attention to the Young for Climate Poland Association which we represent - its mission, values, initiatives and plans.

While presenting different examples of youth activities in Poland, we also tried to answer one more general question: is it worth it to be a climate optimist? We explored different approaches to the climate crisis, especially among youth, and tried to decide which of them is the most beneficial for ourselves and our Planet.

**Keywords:** *Youth; activism; Young for Climate Poland; hope; optimism*

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## WATER – WASTE – ENERGY IN GREEN DEAL

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**Justyna Durak<sup>1</sup>, Katarzyna Styszko<sup>1</sup>, Dariusz Wideł<sup>2</sup>, Elżbieta Sochacka-Tatara<sup>3</sup>**

*Development of a methodology for the determination of hydroxy derivatives of polycyclic aromatic hydrocarbons in wastewater using high-performance liquid chromatography with the UV-Vis spectrophotometric detector*

Polycyclic Aromatic Hydrocarbons (PAHs) are derived from incomplete combustion of organic materials. Their main anthropogenic sources are energy based on burning solid fuels, wood burning, illegal waste burning and transport. Some of these compounds are highly carcinogenic or mutagenic. PAHs enter the human body, mainly by inhalation and through the skin, they are quickly metabolized and leave it within a few days. Metabolized PAHs to hydroxy derivatives (OH-PAHs) of lower molecular weight are excreted mainly in the urine, and those with higher molecular weight are mainly excreted in the bile with the feces. Due to the ease of OH-PAH release into human excreta, OH-PAH can be considered as biomarkers of PAH exposure.

Three OH-PAHs were analyzed: 1-hydroxypirene, 2-hydroxyfluorene, 2-hydroxynaphthalene. A method for the separation of individual compounds using the HPLC/UV-Vis technique was developed - Varian Star liquid chromatograph equipped with a spectrophotometric detector and a Kinetex C18 column (length 7.5 cm, diameter 4.6 mm, 2.6 μm filling in core-shell technology). A gradient elution was used, where the mobile phases were distilled water acidified with acetic acid to pH=3.5 and acetonitrile. Wavelength 210 nm, flow at 0.8 l/min. The linearity of the method ( $R^2 > 0.993$ ) was obtained in the entire range of the analyzed concentrations 1÷30 μg/ml, while the coefficient of variation was below 5%. Determined limits of quantification ranged between 75 and 300 ng/ml. It is assumed that OH-PAH concentrations in real wastewater will be in the order of ng/L, therefore it is required to concentrate the environmental sample by extraction to the solid phase. Efficiency tests were carried out for columns filled with various sorbents. The highest recovery, at the level of 75-95%, was found in the column filled with silica gel modified with octadecyl groups.

**Keywords:** *high performance liquid chromatography; polycyclic aromatic hydrocarbons; metabolism; wastewater*

**Acknowledgments:** *Research financed by Research Subsidy AGH 16.16.210.476.*

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***Jolanta Kozak, Maria Włodarczyk-Makuła***

### *Coke wastewater treatment in the context of water recovery*

The main stream of coke wastewater includes:

- ammonia water, which is a mixture of ammonia water used in the initial cooling of coke gas, condensed water vapor released from the feed mixture and pyrogenic water,
- outflows from benzol rectification and benzol condensation
- outflows from tar processing
- wastewater from gas desulphurization, transformation of hydrogen sulphide into sulfuric acid
- steam condensates used to heat media in technological processes
- outflows from ammonia stripping from coal water
- outflows from hydraulic closures of gas pipes,
- steam condensates from cleaning devices, floors, apparatus, drainage of installation tray.

Their composition and quantity depend on the type of raw material, size and the adopted production technology. They are characterized by a high concentration of organic and inorganic compounds, including those that are not easily biodegradable. Currently, according to BAT recommendations, wastewater is subjected to a multi-stage treatment process on-site coking plant. In order to increase the efficiency of pollutant removal, it is recommended to combine classic unit processes. In the context of reuse of treated wastewater and due to the high pollutant load, treatment is often insufficient. The aim of the study is to evaluate the effectiveness of the application of additional coke wastewater treatment (adsorption, coagulation, membrane separation, advanced oxidation). Based on the literature data and the results of own research, it can be concluded that additional methods can be an effective supplement to the technological line of coke wastewater treatment plants, which will ensure the possibility of using the treated wastewater for industrial purposes.

***Keywords:*** *coke wastewater; polycyclic aromatic hydrocarbons (PAHs); Advanced Oxidation Processes (AOPs); membrane processes; adsorption*

***Acknowledgments:*** *Work was financially supported by subvention of Czestochowa University of Technology.*



**Małgorzata Olejarczyk, Włodzimierz Urbaniak, Iwona Rykowska**

### *Mineral-organic composites based on post-soda lime and paper sludge*

Post-soda lime is a product formed in the process of separating the solid phase present in the still liquid during the production of soda by the Solvay method. It mainly consists of calcium compounds ( $\text{CaCl}_2$ ,  $\text{CaCO}_3$ ,  $\text{CaSO}_4$ ,  $\text{Ca(OH)}_2$ ), magnesium and silica, sulfur, and aluminum compounds. It is characterized by very high hydration, sometimes exceeding 60%, and low particle size distribution (below 2  $\mu\text{m}$ ). These properties limit the possibility of direct mass use of this waste. Hence, intensive research is carried out to develop mineral-organic composites that are used in construction, including road construction. The organic phase consists of fibrous waste - paper sludge, generated during the processing of waste paper (mechanical separation) in paper mills. They are characterized by a high ash content - over 40% and a moisture content of about 50%. Currently, most of the paper sludge is deposited in open landfills. As part of the research, recipes for new composites modifying the properties of the above-mentioned waste materials were developed. New materials with increased mechanical strength compared to the input components were obtained. It has also been shown that due to the high content of various forms of calcium compounds, the tested composite can be supplemented with good results with hazardous mineral waste containing fluorine, e.g. post-crystallization lye formed in the processing of fluosilicic acid or phosphogypsum. The developed composites, thanks to their properties, enable the reuse, especially in construction, of troublesome industrial waste, reducing the consumption of primary raw materials and contributing to the implementation of the circular economy concept.

**Keywords:** *post-soda ash; paper sludge; fluorine waste; mineral-organic composites; closed cycle management*

**Acknowledgments:** *Project co-financed by the Regional Operational Programme for Pomorskie Voivodeship 2014-2020, Project no RPPM.01.01.01-22-0040/18-00.*

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**Paulina Marcinek, Marzena Smol**

## *Bioeconomy in the circular economy – opportunities and challenges for Poland*

Nowadays, modern world economies have to face one of the biggest challenges, which is to minimize the amount of waste and pollution generated, while increasing the use of products that are biodegradable for the environment. The transformation of linear economies into circular models is one of the main priorities in the politics of European countries. In recent years, many of countries have presented strategic documents that include opportunities, barriers and implementation plans for the circular economy (CE) model. Poland is also among the countries in which a lot of emphasis is placed on the good of the environment and in 2019 r. the Council of Ministers approved the document "Transformation towards a circular economy", which is a kind of roadmap. The document contains a list of activities aimed at achieving the CE model and it is emphasized that the bioeconomy is one of the key areas for the implementation of the CE in the country. The bioeconomy is part of the green economy in which biomass is the main raw material used. Biomass has a neutral impact on the environment. The high share of agricultural land in Poland translates into a large biomass potential. The national resources of this raw material are the richest in solid biomass, which includes, inter alia, straw and wood waste.

The objective of the study is to discuss activities aimed at effective transformation towards circular economy in Poland, in the bioeconomy sector, and to present opportunities and challenges resulting from this transformation. The priority activities in the area of bioeconomy include: creating appropriate conditions for its development, building local value chains and raw material base, as well as activities aimed at the transformation of energy and industry. Effective management of renewable resources is another action aimed at introducing the CE model in Poland. Integration between the industry and science sectors is also important, because it may contribute to the emergence of innovative solutions that can be used in the environmental, economic and social areas.

**Keywords:** *bioeconomy; circular economy (CE); sustainable development; biomass*

**Acknowledgments:** *Research realised as the part of the project MonGOS "Monitoring of water and sewage management in the context of the implementation of the circular economy assumptions", no. PPI/APM/2019/1/00015/U/00001/ZU/00002 (2020-2022), financed by the Polish National Agency for Academic Exchange (NAWA) under the International Academic Partnerships Programme. Web-page: [mon-gos.eu](http://mon-gos.eu).*

**MonGOS**



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**Maciej Mróz**

*Security of the natural gas supply to Poland as a transitional energy carrier in the country's energy transition process*

The transition to a climate-neutral economy and the fulfilment of obligations under the Paris Agreement determine the changes in the use of primary energy carriers. Currently, the use of energy from the combustion of fossil fuels (mainly high-emission ones, such as crude oil, coal) is still dominant, what causes significant greenhouse gas emissions. Directionally, the main transitional fuel in the period of Poland's energy transition is to be natural gas, which allows for a significant reduction the emission of the national economy. However, due to the limited coverage of domestic gas demand with own production, it is necessary to import it. The security of natural gas supplies to Poland could be ensured by properly created and successively developed gas infrastructure, which allows for the diversification the sources and directions of gas imports to the country. The aim of the paper is to empirically verify this assumption, and thus to assess to what extent the adopted strategy of diversifying gas imports to Poland, as a low-emission transition fuel, contributes to increase the country's energy security.

**Keywords:** *energy security; infrastructure; natural gas; LNG*



## POSTER SESSION

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**Paweł Wolski**

### *Analysis of rheological properties of thickened sewage sludge*

Sewage sludge is an indispensable product of wastewater treatment process. The current state policy regarding waste management indicated the necessity to search for new technological solutions improving the efficiency of processes related to its disposal. Each activity that intensifies the processes of sludge thickening and dewatering is of great importance for the final product obtained, with specific properties.

The knowledge of rheological parameters in sludge management is essential due to the unit operations they are subjected to. The rheological properties of sewage sludge are best described by mathematical models on the basis of which flow curves and viscosity curves are drawn. If they are omitted when designing, they may contribute to problems related to the operation of sludge management systems. Rheological parameters are also an important control indicator for the dewatering and stabilization processes.

The paper presents the results of rheological tests of excess and digested sludge, which were subjected to thickening after chemical conditioning with polyelectrolytes. The rheological analysis consisted in determining the stresses, viscosity, flow limits and rheological models for the sludge with different amounts of excess water removed. The conducted research showed that with the reduction of sludge hydration, the viscosity and shear stresses (flow limits) increased. The highest values were recorded for the sludge for which the greatest amount of excess water was removed.

**Keywords:** *sewage sludge; rheology; thickening; chemical conditioning*



***Iwona Zawieja, Małgorzata Worwąg, Kinga Brzeska***

### ***Methane Fermentation of sewage sludge sonicated and oxidized with Fenton's reagent***

In order to increase the susceptibility to biochemical decomposition occurring in anaerobic conditions, excess sludge is subjected to the disintegration process using physical, chemical and biological factors, as well as to combined disintegration, combining independent methods. As a consequence, the process of anaerobic stabilization is more intensive, the duration of the hydrolytic phase is shortened and the biogas yield increases. The study aimed to demonstrate that compared to the conventional method, the use of the hybrid method of excess sludge disintegration i.e. combining disintegration with an ultrasonic field and the method of advanced oxidation with Fenton's reagent improves the efficiency of the methane fermentation process. The hybrid method was considered the most effective since for the most favourable modification conditions, the highest increases in the value of SCOD and the concentration of VFAs were recorded compared to non-disintegrated sludge. The dose of iron ions of 0.04 g Fe<sup>2+</sup>/g TS, the Fe<sup>2+</sup>: H<sub>2</sub>O<sub>2</sub> ratio of 1:3, the ultrasonic field vibration amplitude of 16 μm and sonication time of 360s were considered the most favourable conditions for conducting the hybrid disintegration process. A similar effectiveness of the disintegration process was obtained in the case of excess sludge disintegration with the hybrid method with doses of iron ions in the range of 0.06 ÷ 0.12 g Fe<sup>2+</sup>/g TS. In the process of methane fermentation of excess sludge disintegrated with an ultrasonic field, Fenton's reagent and combined disintegration, the highest value of SCOD and VFA concentrations were recorded for the hybrid method with the iron ion dose of 0.04 g Fe<sup>2+</sup>/g TS while maintaining the ratio of Fe<sup>2+</sup>: H<sub>2</sub>O<sub>2</sub> 1:3. For the above preparation conditions, the digestion degree was 63% and the biogas yield was 0.54 L/g VSS.

***Keywords:*** methane fermentation; excess sludge; ultrasonic field; Fenton's reagent; biogas yield

***Acknowledgments:*** The scientific research was funded by the statute subvention of Czestochowa University of Technology, Faculty of Infrastructure and Environment.





***Halyna Kominko, Katarzyna Gorazda, Zbigniew Wzorek***

### *Sewage sludge - a circular raw material for dedicated organo-mineral fertilisers*

In the light of natural resource depletion and environmental pressure searching of alternative raw materials for fertilizer production is a relevant issue. Sewage sludge is an attractive fertilizer source with high organic matter and nutrient content. Taking into account sewage sludge soil-forming properties and challenges of their management, sewage sludge can be used for manufacturing of organo-mineral fertilizers. In this study, the recipes of organo-mineral fertilizers with dedicated composition in the granular form were developed.

The manufacturing process of organo-mineral fertilizer consists of enriching of dried sewage sludge with nutrients and granulating of obtained mixture with acid solution in a pan granulator. Final products are characterized by dedicated composition for rapeseed, sunflower and corn crops and total nutrient content about 20%, which is typical for mineral fertilizers. Moreover, they are rich in secondary nutrients (Ca, Mg, S), as well as micronutrients (Cu, Zn, B, Fe, Mo), which increases their market value. Organo-mineral fertilizers fulfil the requirements regards to heavy metal content and sanitary condition according to Polish legislation.

The agricultural efficiency of obtained organo-mineral fertilizers was confirmed in pot trials. Using of organo-mineral fertilizers based on sewage sludge causes biomass increase by 23-138% in comparison with control sample depending on a dose of fertilizer and tested plant.

Using sewage sludge for organo-mineral fertilizer manufacturing can be a solution to their management for small or medium wastewater treatment plants having sewage sludge with low pollution load. It allows for nutrients and organic matter recycling in line with circular economy concept.

***Keywords:*** *circular economy; sewage sludge; nutrient recycling; organo-mineral fertilizers*



**Michał Preisner<sup>1</sup>, Marzena Smol<sup>1</sup>, Elena Neverova-Dziopak<sup>2</sup>, Zbigniew Kowalewski<sup>2</sup>**

*Application of activated sludge model (ASM) for phosphorus (P) recovery potential simulation*

The study investigates phosphorus (P) recovery potential from sewage sludge in the most prevalent activated sludge (AS) systems obtained with an Activated Sludge Model (ASM) simulation using BioWin software by EnviroSim Associates Ltd. The simulation study includes 10 various wastewater treatment systems. The analysed systems were based on the following technologies: conventional activated sludge (CAS), anoxic-oxic (AO), 3-stage Bardenpho, 5-stage Bardenpho, Johannesburg (JHB), modified JHB system (MJHB), University of Cape Town (UCT), modified UCT system (MUCT), oxic-anoxic (OA) and anaerobic-oxic (A/O). The ASM-based simulation allowed to develop P flows diagrams for 10 analysed AS systems considering the effluent P load discharged to wastewater receiver and P recovery potential estimated on the base of total phosphorus content (TP) and inorganic phosphorus (IP) content in the sewage sludge. The range of the P recovery potential based on TP content in the sewage sludge reached from 1.33% in the JHB and MJHB systems to 1.01% in the OA system. The study covered the P bioavailability context by analysing the simulation results of the IP content in the sewage sludge which varied from 0.19% in JHB and MJHB systems to 0.05% in the OA system.

**Keywords:** *sewage sludge; phosphorus recovery potential; wastewater treatment; phosphorus flow; activated sludge model*

**Acknowledgments:** *Research carried out under the Subvention of the Division of Biogenic Raw Materials at the Mineral and Energy Economy Research Institute, Polish Academy of Sciences and the Subvention of the AGH University of Science and Technology.*

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### *Water quality changes in the integrated coagulation and sorption process*

The aim of the research was to determine the effect of the addition of powdered activated carbon on the water quality during coagulation. The studies used the PAX XL 19H coagulant in the amount of 3.6 mg Al·L<sup>-1</sup> and the powdered active carbon CWZ-22 in the amounts of 20 to 100 mg·L<sup>-1</sup>. In raw water, after coagulation and the integrated coagulation process supported by active carbon, the following values were determined: pH, true color, turbidity, dissolved organic carbon and UV absorbance. In surface water, the true color and turbidity were respectively 150 mgPt·L<sup>-1</sup> i 21.5 NTU. After the coagulation process, the true color was 70 mgPt·L<sup>-1</sup> and the turbidity was 4.2 NTU. In the case of the integrated coagulation and sorption process, the true color value decreased from 53 to 70%, and the turbidity from 84 to 87%. The value of absorbance UV254 and DOC in raw water was 12.9 m<sup>-1</sup> and 12.0 mgC·L<sup>-1</sup>, respectively. After coagulation, the absorbance UV254 and DOC values were 9.4 m<sup>-1</sup> and 11.0 mgC·L<sup>-1</sup>, respectively, while after coagulation and sorption, the absorbance UV254 and DOC values decreased by 38 to 56% and 8 to 25%, respectively. The value of SUVA before the process was 1,075 m<sup>3</sup>·gC<sup>-1</sup>·m<sup>-1</sup>, after the coagulation process it decreased by 21%, and after the integrated process by 38 to 41%. Along with the increase in the dose of powdered activated carbon, the values of absorbance UV254, DOC and SUVA decreased gradually.

**Keywords:** *coagulation; active carbon; pre-hydrolyzed coagulants*

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**Edyta Łaskawiec**

### *Assessment of the quality of sludges from washings from the swimming pool water system*

Post-coagulation sludge, coagulants, fibers, epidermis, micropollutants, and macromolecular compounds constitute the main contaminants which can be found in the washings coming from rinsing the filters in swimming pool facilities. Taking into consideration the potential for the recycling of washings, one also has to take into account the possibilities of managing the sludge, which is present in large amounts in the washings.

A physicochemical and ecotoxicological analysis of sludge samples collected from the washings out of swimming pool and the common whirlpool-swimming pool circuits was conducted. The research focused on an analysis of the dynamics of the sedimentation processes of the sludge in the washings over a period of 24 hours. A particle size distribution in a gravitationally condensed sludge was prepared with the application of the laser diffraction method. The phytotoxic effect of the sludge samples in growth inhibition of *L. minor*, *S. alba*, and *R. sativus* was assessed.

The content of the easily-settling sludge in the examined washings was in a range between 3.2÷10.8%. The particle size distribution in the washings differed depending on the circulation as well as on a single intake. However, particles in the range of 1÷100 µm were the most numerous. The phytotoxicity of the sludge was diversified and depended strongly on the percentage of the sludge in an individual sample being tested. Sludge samples with a concentration in a range of 80 – 100% of the volume in deionized water were much more frequently classified as toxic (the number of chloroses and necroses in *L. minor* fronds also increased).

**Keywords:** *pool water; washings; ecotoxicology; particle size distribution; dynamics of sedimentation*



**Ewa Wiśniowska**

*Methods of heavy metals removal from wastewater in the aspect of generated waste products of the processes*

Heavy metals are discharged to various industrial wastewater. They pose a serious risk for the environment because they are toxic and accumulate in water organisms. The important problem is that they are not removed during typical technological processes in wastewater treatment plants, such as activated sludge treatment. A lot of research papers are focused on heavy metals removal from wastewater. Various processes are used for this purpose, including adsorption (on commercial adsorbents or bio-adsorbents), chemical precipitation, ion exchange, or membrane filtration. Most studies describe the effectiveness of heavy metals removal depending on various parameters, eg. pH, hydraulic retention time, filtration rate, or other characteristic for the individual method. Based on the removal efficiency under various conditions (more or less comparable), the recommended method is usually indicated. Economic efficiency plays a very important role in this type of evaluation, as well as ecology, but the ecology is usually considered in the aspect of the kind of adsorbent or other chemicals used. Few studies analyze the problem of the waste products generated as a result of heavy metals removal. The present study focuses on this rarely discussed aspect of heavy metals removal. Characteristics of the waste products generated as a result of various methods of selected heavy metals removal are given. Based on the characteristics of the waste products some suggestions of management strategies are presented. This approach allows for showing a different perspective on the heavy metals removal technologies.

**Keywords:** *adsorption; heavy metals; industrial wastewater; waste products*

**Acknowledgments:** *The paper was funded by the statute subvention of Czestochowa University of Technology, Faculty of Infrastructure and Environment.*



***Rūta Ozola-Davidāne, Māris Kļaviņš, Marta Jemeljanova, Linda Ansone-Bertina***

## *Humic substances for the removal of inorganic and emerging organic pollutants from wastewater*

Humic substances are high-molecular-weight polycationites which are formed from long-term physical, microbial and chemical transformations of organic matter. Nowadays, humic substances are produced at the industrial scale, and they can also be obtained from waste materials, such as compost. The polyfunctional materials humic substances strongly interact with organic and inorganic substances. Therefore, they can be used as sorbents to remove emerging pollutants (trace metals, metalloids, and pharmaceuticals, etc.), which are insufficiently treated by current wastewater treatment methods. In this study, humic substances were treated by two methods, i.e., immobilization and intercalation into clay mineral's structure, to develop environmentally friendly and cost-effective sorbents for applications in wastewater treatment. Also, to our knowledge, up to now, immobilized humic substance sorbents are not widely studied as sorbents. Results from characterization methods (SEM, TGA, BET, XRD, FTIR etc.) indicated that immobilization of humic substances and intercalation into clay material has been successful. The newly developed sorbents demonstrate high sorption capacity with respect to metal ions - Cr(III), Cu(II), and As(V), as well as pharmaceuticals - chlorpromazine.

**Keywords:** *humic substances; clay minerals; sorption; metal ions; pharmaceuticals; wastewater treatment*

**Acknowledgments:** *Research realised as the part of the project MonGOS "Monitoring of water and sewage management in the context of the implementation of the circular economy assumptions", no. PPI/APM/2019/1/00015/U/00001/ZU/00002 (2020-2022), financed by the Polish National Agency for Academic Exchange (NAWA) under the International Academic Partnerships Programme. Web-page: mon-gos.eu.*

**MonGOS**



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**Maibam Dhanaraj Meitei<sup>1</sup>, Majeti Narasimha Nara Prasad<sup>2</sup>**

***Phytofiltration of iron contaminated waters using *Typha latifolia* L in laboratory - scale microcosms***

The study reports the preliminary information on the phytofiltration of iron contaminated waters and aggravation of iron uptake by copper supplementation using *Typha latifolia* L in constructed microcosms. The experiment showed iron (Fe) concentrations reduced up to  $1.67 \pm 0.076$  mg L<sup>-1</sup> (94.43 % removal efficiency) and  $0.087 \pm 0.013$  mg L<sup>-1</sup> (97.10 % removal efficiency) by 14<sup>th</sup> day from the initial concentrations of 30 mg L<sup>-1</sup> in the microcosm set up's. Iron accumulation in the plant tissues were  $2425.65 \pm 41.01$  mg kg<sup>-1</sup> (Fe with copper - Cu) compared with  $1446.00 \pm 36.01$  mg kg<sup>-1</sup> (without Cu) revealing that Cu addition in the microcosm set up magnify Fe accumulation and removal. Thus, the results signify that constructed wetlands (CW) can serve as the low cost, eco-friendly alternative for wastewater treatment.

**Keywords:** *phytoremediation; wastewaters; Typha latifolia; iron; constructed wetlands*

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***Iwona Deska***

### ***The impact of the mosses growth on the water retention capacity of green roofs***

The urbanization and the population growth leads to an increase of the impermeable surface areas in the cities. This results in an increase of both the surface runoff and the risk of flood. Therefore, there is a need to apply the strategies and solutions that can support the operation of traditional drainage systems in the urban areas. Examples of such solutions are green roofs that can be counted as Green Infrastructure (GI) and Low Impact Development (LID) measures. The goal of the research was to investigate the retention capacity of seven extensive green roof modules (60 × 60 cm). In the case of five modules the substrates were amended with the superabsorbent polymer (the cross-linked potassium polyacrylate). Six modules were vegetated with goldmoss stonecrop. Additionally, all vegetated modules were partially covered with mosses. The share of areas covered with mosses ranged from 6,7% (in the case of relatively new module) to about 43,0% (in the case the oldest vegetated module containing hydrogel). The obtained results show that the green roofs may have a positive effect on the stormwater management. The best retention capacity was exhibited by the relatively new modules containing the plants and hydrogel admixtures. On the other hand, the lowest retention capacity was exhibited by the oldest module mostly covered by mosses. The obtained results suggest that the overgrowth of mosses on the green roof may decrease their retention capacity under certain atmospheric conditions (especially at high levels of the air relative humidity).

***Keywords:*** green roof; retention capacity; moss; superabsorbent polymer; hydrogel

***Acknowledgments:*** The scientific research was funded by the statue subvention of Czestochowa University of Technology, Faculty of Infrastructure and Environment.





**Małgorzata Widłak, Robert Kowalik, Szymon Sobura**

*The quality of the soil and water environment in the immediate vicinity of the  
Barania Góra Forest Reserve*

The aim of the study was to determine the content of selected fractions of bioavailable trace elements (Cd, Cr, Ni, Cu, Pb, Zn), the content of nonpolar aliphatic hydrocarbons in agricultural soils and the quality of drinking water from the Strawczyn intake. The soil material for the research was collected from 4 arable lands located within the Barania Góra Reserve and water from the deep wells. The direction of watercourses from the area of the reserve and agricultural fields around the reserve supplying the drinking water resources of the intake in Strawczyn was determined. The tested soils had a neutral pH, the organic carbon content ranged from 0.92% to 1.02%. The bioavailable forms of the examined elements were characterized by a different percentage content between individual samples. In all tested soils, the highest percentage was the fraction with organic matter in the range of 9.1-27.4% and the residual fraction in the range of 50.3-75.2%, in which the immobilized metals accumulate in the residue insoluble in concentrated acids. The metals of this fraction are chemically stable and biologically inactive. The pH values of the tested soil from all areas were in the range of pH 6.6-pH 7.5, and the content of nonpolar aliphatic hydrocarbons was on average 26.74 mg / kg in all areas.

The quality of drinking water from the deep water intake in Strawczyn is at the level of drinking water from the Zagnansk intake for residents of the city of Kielce. Water in Kielce is characterized by high nutritional and health values. It is low-mineralized, low-fluoride water, containing a large group of microelements beneficial to health, with an overall hardness of 202 mg of CaCO<sub>3</sub>, medium hardness water.

**Keywords:** *sequential extraction; heavy metals; mobility of heavy metals; drinking water*

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**Joanna Jabłońska<sup>1</sup>, Mariusz Kluska<sup>1</sup>, Nikolai Erchak<sup>2</sup>**

*The electrostatically stabilised silanate as a non-toxic terminating electrolyte for the isotachopheresis technique*

The isotachopheresis technique (ITP) is used as a green alternative to classical measurement methods. Two different electrolytes (the leading electrolyte and the terminating electrolyte) are applied in isotachopheresis. A mixture of separated ionic substances is inserted between these systems. The terminating electrolyte proposed herein by the authors to be used in ITP analysis belongs to the electrostatically stabilised silanates (ES-silanates). The new terminating electrolyte is a well water-soluble, hydrolytically stable compound, which can remain in water solutions in unchanged form for a long time. Furthermore, the compound is biodegradable and non-toxic to the surrounding environment. Having considered the above advantages, its high molecular mass and the fact of its existence as a dual ion, the compound was used as a terminating solution in ITP analyses. The use of the new-generation electrolyte enables analyses of cations and anions without the need to change the electrolyte and within a much wider pH range (3–12) than other commercially available electrolytes described in literature. The objective of this work was to develop a new-generation terminating electrolyte and employ it in studies with the use of test substances. Feasibility of the new electrolyte use was successfully confirmed.

**Keywords:** *electrostatically stabilised silanates; terminating electrolyte; isotachopheresis; green chemistry technique*

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***Agnė Šleiniūtė, Tamari Mumladze, Gintaras Denafas***

***A review on separation of composite materials, based on recycling of food packaging, pharmaceutical blister packs and photovoltaic cells wastes***

The purpose is to review on the separation of composite materials (CMW), from food packaging (FOR), pharmaceutical blister packs (WPBs) and photovoltaic cells wastes (PVC). All mentioned type of composite materials generally consist of several layers and different kinds of raw materials, such as polymers, silicon, aluminium, glass, etc. The high increase in the usage of this kind of composite materials also become the reason for increases the waste generation thus creating new environmental and economic challenges. The different research work had done by researchers in field of recycling and progress in the recovery and management of CMW by several methods along with the various separation techniques. Based on the previous studies, chemical separation can be considered as the most suitable separation method for CMW. The results showed that after separation the selected raw materials (i.e. polymers, aluminium, silicon) were recovered in acceptable conditions. Therefore, CMW can be used in different areas of production and industry. Based on the literature review on results of life cycle assessment (LCA), the environmental impacts of CMW treatment were highest for landfill disposal, followed by incineration and then recycling. Based on different data and literature it is required to extract an enormous amount of raw materials from nature, which at the same time has a high cost, that means that composite materials' treatment can decrease of using natural resources. Thus, recovery materials from CMW can be considered as an environmentally friendly and economical favourable way.

***Keywords:*** *composites packaging waste; recycling; recovery materials; aluminium; polymers; sustainability*



**Inna Pitak, Arūnas Baltušnikas, Gintaras Denafas**

### *Analysis of separated waste for the preparation of solid recovered fuels*

Many countries in the world try to limit production of wastes through implementation of policies for waste reduction. Increasingly large amounts of wastes are produced on our planet every year. The paper presents an analysis of municipal solid waste (MSW) after separation, which can be sent to Waste-to-energy plant.

Mechanical-biological treatment (MBT) plants are designed to further treat mixed collected or residual municipal solid waste. The main aim is to extract further value from the waste and to recover the energy contained in it while facilitating recycling and diversion of waste from landfills.

The paper presents activities of Kaunas MBT plant in period July - October 2020. The results are consistent with average rainfall data in the period under review. This fact suggests that the moisture content is influenced greatly by both the manufacturing and atmospheric conditions, thus different conditions in the storage of the different fractions could result in large deviations in final moisture content. The paper describes average value of different waste streams, their morphological composition, volatile matter, fix carbon, ash and moisture content. All of these parameters differ considerably with the considered month. Moreover, the morphological composition, volatile matter, fix carbon, ash and moisture content of waste varies depending on the season ability, being the textile and paper fraction the highest contribution, as it could be expected. The standard deviations for this kind of waste are usually quite high, since the waste composition may change throughout the year according to the population behaviour.

The separation and physical/chemical treatment of Refuse Derived Fuel (RDF) can be exploited to maximize the energy recovery.

**Keywords:** *municipal solid waste (MSW); separation; refuse derived fuel (RDF); solid recovery fuel (SRF)*

**Acknowledgments:** *We would like thank Marius Praspaliauskas, Senior research associate, Laboratory of Heat-Equipment Research and Testing, LEI to help in preparing materials for the experiment.*

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### *REDU Iași - a circular fashion initiative in Romania*

Romania is a landfill-based country where mixed waste collection still prevails. The recycling rate in Romania was around 14 % in 2017 and European targets set up for 2020 will not be achieved. The transition towards a circular economy depends on innovative projects as best practices models that could catalyse the efforts in the right direction among Romanian stakeholders in the coming years. This work aims to point out the impact of a circular fashion project started in Iasi city on the local community as an environmentally friendly alternative to the mainstream textile industry. REDU is the first social enterprise in Romania to create new and improved products from pre-consumer and post-consumer textiles, and the first initiative in Iasi to collect old and used materials from the community to reuse. REDU uses secondary materials from local (Iasi city) and regional industries (North-East Region) while post-consumer textile waste fraction is not source-separated from households and it is still disposed of in landfills as residual waste. In five operational years, about 20 Mg of textile waste were collected and over 6300 new products were made. The REDU project encourages the consumer shift towards the slow fashion model which complies with top circular economy principles (refuse, rethink, reduce, reuse, repair, recycle) and the sustainable development goals such as SDG12 - responsible production and consumption. The circular fashion approach started with REDU project will be further developed as a partner in HEREWEAR Horizon 2020 project which focuses on bio-based local sustainable circular wear.

**Keywords:** *circular fashion; circular economy; slow fashion; upcycling; textile waste; waste management*

**Acknowledgments:** *Research realised as a part of REDU project, Romania.*

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**Andrei Orlov<sup>1</sup>, Sergei Levchenko<sup>2</sup>**

### *Cluster analysis of circular economy indicators in the European Union*

In 2015, the European Commission adopted an ambitious Circular Economy Action Plan, which includes measures that will help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs. A second Circular Economy Action Plan will make up “half” of the carbon cuts expected under the Green Deal. The circular economy, including new waste and recycling laws, will represent “half” of the European effort to achieve net-zero carbon emissions by 2050, and will be erected as “the number one priority” of the upcoming European Green Deal. The research objective was to analyse the circular economy indicators in the European Union (EU) referred to building the clusters of Member States. In order to generate the clusters, we applied the  $\kappa$ -means clustering method based on the data obtained from Eurostat. The indicators of the circular economy are circular material use rate, trade in recyclable raw materials. By using the STATISTICA software package, some clusters of countries have been generated. Then the main characteristics of the circular economy policy in each cluster of countries of the EU were highlighted. The conducted cluster analysis made it possible to distinguish states having highest the circularity rate (Netherlands, France and Belgium). The results of the analysis can be applied to develop a decision support system for the formation of recommendations in the European Green Deal and the activities in the field of the circular economy.

**Keywords:** *European Union; cluster analysis; circular economy; circular material; recyclable raw materials*

**Acknowledgments:** *This research work was supported by the program Erasmus+ Jean Monnet Projects “The circular economy: “the number one priority” for the European Green Deal” (CIRECON) № 619927-EPP-1-2020-1-BG-EPPJMO-PROJECT.*

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***Brahim Arhoun, María Villen-Guzman, María del Mar Cerrillo-Gonzalez, Juan Manuel Paz-García, José Miguel Rodríguez-Maroto***

***Biosorption of cadmium from aqueous solution using agri-food industry wastes***

The agri-food industry generates a large amount of easily biodegradable waste which can pose a potential risk to the environment. At the same time, other industries can generate harmful metals that risk the environment and public health. The removal of heavy metals from aqueous effluents can be achieved by various methods such as precipitation, electroplating and ion exchange. The processing costs and sludge production are key factors for selecting a treatment technology. Biosorption is a low-cost alternative that not only makes possible to take advantage of waste from agri-food industry but also allows the removal of heavy metal from industrial effluents.

In this study, the enhancement of the adsorption capacity of lemon peels to remove Cd (II) ions from aqueous effluents was investigated using NaOH as surface modifier. The biosorbent surface was characterized by Brunauer-Emmett-Teller (BET) method and Scanning Electron Microscopy. The study of surface functional groups was performed by Fourier transform infrared spectroscopy. The influence of contact time, pH, and adsorbent dosage on the adsorption process were analysed. The maximum adsorption capacity was 80.5 mg g<sup>-1</sup> according to the *Langmuir* model at optimum conditions (pH=5, S/L=5 g L<sup>-1</sup>, 25°C). Biosorption kinetics followed a pseudo-second order. After five consecutive adsorption-desorption cycles using 0.1M of HNO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub>, a recovery of 70% of Cd (II) was obtained.

To conclude, treated lemon peel can be used as an effective and low-cost biosorbent for the removal of Cd (II) from aqueous solutions.

***Keywords:*** biosorption; lemon peel; cadmium ions; surface characterization

***Acknowledgments:*** The University of Malaga is acknowledged for the postdoctoral fellowship of Villen-Guzman. Cerrillo-Gonzalez acknowledges the FPU grant obtained from the Spanish Ministry of Education, FPU18/04295.



***Brahim Arhoun, María Villen-Guzman, María del Mar Cerrillo-Gonzalez, Juan Manuel Paz-Garcia, José Jimenez-Jimenez, José Miguel Rodriguez-Maroto***

### *Phosphorus removal from municipal wastewater*

This work focused on a wastewater treatment plant (WWTP) located in the south of Spain (Antequera, Spain) which requires a higher phosphorus removal efficiency to comply with the legal limits of emission (European Communities, 1991). Currently, technologies for recovering phosphorus from municipal wastewater are mainly based on Struvite/Ca-P precipitation from anaerobic sludge. However, with the aim of reducing sludge production, Antequera WWTP was equipped with an extended aeration activation sludge system as biological treatment. Due to the implementation of stricter environmental legislation concerning phosphorus emissions, other methods of phosphorus removal should be proposed.

This work is based on 1) description of mass balances and chemical equilibrium conditions for all the species of interest under usual operating conditions, 2) phosphorus removal in discontinuous operation at lab scale, 3) phosphorus removal in continuous operation at lab scale, 4) selection of the most efficient treatment and design of pilot plant, 5) implementation of chemical phosphorus removal at full scale.

The effect of ferric chloride addition in phosphorus removal was evaluated in batch systems using synthetic and real wastewater. The influence of the most relevant operating condition, such as pH (5-8) and Fe/P ratio (1-8), was assessed using synthetic wastewater. The maximum recovery of phosphate was of 98.6% at optimum conditions (pH values between 5-8 and Fe/P ratio of 2.5). The pH values of sludge samples after ferric chloride addition were maintained constant which has been associated with the high buffer capacity of sludge in real wastewater. Experimental results indicate that phosphate's chemical precipitation by Fe(III) is a suitable method to remove phosphorus from wastewater.

***Keywords:*** wastewater treatment plant; chemical precipitation; phosphorus removal; lab-scale

***Acknowledgments:*** The authors acknowledge the financial funding from the Program “Ayudas a actividades de transferencia de conocimiento entre los agentes del sistema andaluz del conocimiento y el tejido productivo. Consejería de Economía, Conocimiento, Empresas y Universidad. Junta de Andalucía”. Ref. AT17\_5576.





**Livija Zarina**

### *Nitrogen pollution in wastewater depending on the type of catch crop mixtures*

Nitrogen pollution is one of today's major environmental challenges in the world. One of the sources of nitrogen pollution to water courses is nitrogen-laden runoff from agricultural fields originated from synthetic fertilizers, as well as from livestock manure application to provide plants with nutrients. The cultivation of catch crops is considered to be one of the important environmental measures to reduce the leakage of nitrogen compounds in surface and coastal waters. Various plant species can be used as catch crops, provided they are characterized by rapid growth at an early stage of development. Since 2017, a study on catch crops grown in Latvia has been carried out at the Institute of Agricultural Resources and Economics' Crop Management Department.

The aim of the study was to find out the effectiveness of the most common catch crops grown in Latvia (white mustard, oilseed rape, rye, oat, Italian ryegrass, faba bean, and phacelia) in the binding of nitrogen when they grow in mixtures. The catch crop mixtures compared were: rye & white mustard, oat & white mustard, oat & Italian ryegrass, white mustard & oil radish. Catch crops were sown immediately after the main crop (winter wheat) harvesting. Wastewater samples were taken at the end of the current season and at the beginning of the following season. Nitrogen accumulation was evaluated using the method accordingly LVS EN ISO11905-1:1998. At the end of the season, the amount of nitrogen recorded in samples per variant ranged from 2.7 to 17.8 mg L<sup>-1</sup>, at the beginning of the next vegetation from 2.2 to 16.2 mg L<sup>-1</sup>. Among compared mixtures, the best N binders were oat & white mustard.

**Keywords:** *nitrogen leaching; catch crops; agriculture*

**Acknowledgments:** *This study was implemented thanks the financial support of the Interreg V-A Latvia-Lithuania Cross Border Cooperation Programme 2014 – 2020 project „Optimal catch crop solutions to reduce pollution in the transboundary Venta and Lielupe river basins”. We sincerely thank the Lielvaiceni farmers for excess to their fields and support in data collection.*

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***Małgorzata Frosik, Agnieszka Bitner***

*An example of floodplain development – a case study of the Niepołomice  
Commune*

The whole Niepołomice Commune is located alongside the Vistula River. There is a bicycle route in the embankment (a part of the Vistula Cycling Route). Niepołomice Commune has specific topography – its area is situated on flat terrain, only slightly elevated above the level of the Vistula riverbed. A large number of undeveloped land properties (without possibility of building development) is located on the both sides of the flood embankment. The aim of the study was to show an example of floodplain development in the Niepołomice Commune. The paper presents the result of statistical analysis of real estate transactions using data from the period 2016-2019. The data concerns undeveloped land properties (without the possibility of building development) from Niepołomice Commune. The results show that plots located in floodplains may be attractive areas for recreational purposes. The unit prices of undeveloped land properties in the floodplain used for recreational purposes do not differ from the unit prices of undeveloped land properties (without the possibility of building development) located outside the floodplains in the Niepołomice Commune.

***Keywords:*** *floodplain; real estate; Niepołomice*



**Malgorzata Worwag**

### *Treatment of landfill leachate and the possibility of recovering heavy metals*

Landfill leachate is a serious threat mainly due to the high load of pollutants, toxic substances (including heavy metals) and refractive substances. The changing characteristics of the leachates make it difficult to clean them, especially when the proportion of components is different, also over time. For this reason, one or more recommended methods for the treatment of leachate cannot be distinguished. The selection of the appropriate leachate treatment method depends on the chemical composition of the leachate and its susceptibility to biodegradation. In addition, the leachate treatment method should enable changes and modernization of the technology as the nature of the leachate (composition and quantity) or treatment requirements change. Heavy metals present in the leachate can inhibit biological processes, which makes their treatment difficult. Therefore, the leachate can be a source of recovery of heavy metals, especially in large quantities. This work presents the review of the methods of leachate treatment, heavy metal recovery and integrated solutions used.

**Keywords:** *landfill leachate; heavy metals biological treatment*

**Acknowledgments:** *The study was carried out in the framework of the statutory funds for research, financed by the Ministry of Science and Higher Education.*



**Marcin Głodniok, Paweł Zawartka, Bartłomiej Bezak**

*Mine tailings and municipal organic wastes as a substrates for soil substitutes production*

Post-mining waste is a significant challenge for its management and transformation based on the principles of the circular economy. According to the concept of the new green deal, the use of organic and mineral waste is part of the respect of natural resources and the closing of the phosphorus and nitrogen cycle in nature. Work on the development of a recipe for soil-forming material was based on the preliminary results of stone tests provided by Polska Grupa Górnicza S.A. and on the test results for sewage sludge collected from the municipal sewage treatment plant in the Silesian agglomeration. The obtained research showed that on average 60% of the stone composition is SiO<sub>2</sub> silica, about 4% of potassium in the form of K<sub>2</sub>O oxide, approx. 1% CaO, approx. 1.5% MgO of valuable nutrients for plants. Nitrogen and organic matter are not present in the mentioned rock. Valuable organic components of fertilizer products will be delivered to the mixture in the form of municipal sewage sludge. Mine tailings from three streams from different locations of the Polska Grupa Górnicza SA deposit was used for research on the recipe. Such use of samples made it possible to compare a wide spectrum of physicochemical properties of the aggregate, and made it possible to presume repeatability of the quality of the resulting product, regardless of its location. In the first step, the stone was crushed and ground, then homogenized with sewage sludge in a dynamic counter-rotating mixer. One of the basic assumptions of this research work was to create the target form of the expected product of transforming post-mining stone. In order to give the product an attractive market form, it was established that it should be in the form of durable non-dusting granules that are easy to pack, transport and use in agro technical operations (also with the use of standard agro technical tools).

**Keywords:** *mine tailings; organic municipal waste; soil substitutes*



**Maria Villen-Guzman, Brahim Arhoun, Carlos Jimenez, Jose Miguel Rodriguez-Maroto**

### *Biosorption of Pb (II) from aqueous solutions on Spirulina*

The increasing pollution of heavy metals in the environment due to industrial activity poses serious risks for human health and living organism. Biosorption is proposed as an emerging and low-cost alternative based on the sorption of dissolved solutes on a biomaterial. Among low-cost biomaterials, algae have been widely proposed as an ideal option for the removal of heavy metals from water effluents.

In this study, *Spirulina* was proposed as a biosorbent to remove lead from aqueous solutions. The influence of the pH value and ionic strength of the aqueous solution on the biosorption of lead (Pb) ions on *Spirulina* was evaluated at batch system. With the aim of assessing isotherm data, *Freundlich*, *Langmuir* and *Dubinini-Radushkevich* models were used to simulate experimental results. These models described the biosorption process with high correlation coefficients. The Langmuir isotherm showed a better fit to the experimental data. Hence, the Pb(II) biosorption can be regarded more likely with monolayer adsorption as concluded in previous studies dealing with biosorption of metals onto algae. From *Dubinini-Radushkevich* parameters, it was concluded that the uptake of Pb onto *Spirulina* surface is of physical nature which is of interest for industrial application of adsorption. The *Spirulina* presents promising characteristics to be used in column applications as an inexpensive biosorbent material for the recovery of wastewater contaminated with Pb(II).

**Keywords:** *biosorption; algae; wastewater; lead Pb (II); Spirulina*

**Acknowledgments:** *The University of Malaga is acknowledged for the financial support in the postdoctoral fellowship of Villen-Guzman.*



***Maria Villen-Guzman, Maria del Mar Cerrillo-Gonzalez, Brahim Arhoun, Juan Manuel Paz-Garcia, Jose Miguel Rodriguez-Maroto***

### *Recovery of Critical Raw Materials from LiCoO<sub>2</sub> by reductive acid leaching*

The growing use of Lithium-Ion Batteries (LIBs) in portable electronic devices and electric vehicles involves the production of spent LIBs which present a threat to ecosystem and human health. Furthermore, some components of LIBs have a high economic value associated with valuable metals such as lithium, nickel, and manganese. As the recovery of these metals involves relevant economic and environmental benefits, the development and optimization of recycling processes is gaining importance.

This work focuses on the hydrometallurgical recovery of cobalt and lithium, classified as Critical Raw Materials (CRMs) due to their supply risk and economic importance. Batch extraction experiments were carried out using LiCoO<sub>2</sub> as one of the most used oxides as cathode in LIBs. As it is widely accepted, the addition of reductants agents in acid leaching processes is proposed to significantly improve leaching efficiency. The purpose of this research was to evaluate the role of hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) in the leaching process to maximize the amount of cobalt and lithium recovered from LiCoO<sub>2</sub>. With this aim, the concentration of H<sub>2</sub>O<sub>2</sub> was varied from 0 to 0.6 %v/v while the extracting agent (HCl) concentration was increased from 0.5 to 2.5 M. According to experimental results, the acid concentration has a direct effect on the reaction rate while the concentration of H<sub>2</sub>O<sub>2</sub> played an important role in the extraction yield.

***Keywords:*** *lithium ion batteries; leaching; hydrogen peroxide; cobalt and lithium recovery*

***Acknowledgments:*** *This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 778045. The University of Malaga is acknowledged for the financial support in the postdoctoral fellowship of Villen-Guzman and the project PPIT.UMA.B5.2018/17. Cerrillo-Gonzalez acknowledges the FPU grant obtained from the Spanish Ministry of Education. Paz-Garcia acknowledges the financial support from the program "Proyectos I+D+i en el marco del Programa Operativo FEDER Andalucía 2014-2020", No. UMA18-FEDERJA-279.*



**Michał Preisner**

### *Wastewater treatment plants as an enabler of industrial symbiosis*

The study presents the importance of wastewater treatment plants (WWTPs) in the development of industrial symbiosis. Industrial and municipal effluents are currently considered more often as a hydrotransport of resources rather than the discharge of pollutants as it was in the previous decades. Nutrients, organics, cellulose, trace metals and energy can be recovered using various technologies at WWTPs. Industrial symbiosis can be achieved in municipal WWTPs by increasing the range of collected wastewater to not only urban effluents but also wastewater from some industries with a high content of valuable raw materials. Dairy, food and beverage production are among the most interesting sources of materials which can be used in the industrial symbiosis. Recovered biogenic materials such as nitrogen and phosphorus are used for fertilizers production along with organic matter from digested sewage sludge. They can be applied in agriculture and improve the crop yields which further on are sold to the dairy and food and beverage producers.

**Keywords:** *industrial symbiosis; wastewater treatment plants; WWTP; nutrients; organics; agriculture; fertilizers; biogas; digestate*

**Acknowledgments:** *Research carried out under the Subvention of the Division of Biogenic Raw Materials at the Mineral and Energy Economy Research Institute, Polish Academy of Sciences.*



**Monika Galwa-Widera, Anna Kwarciak-Kozłowska**

*Biofiltration as an ecological method of removing odors from solar drying of sewage sludge - a case study*

The emission of odor compounds is a serious problem for the environment. The complaints from the residents of nearby houses about discomfort indicate that this is not a sufficiently resolved problem and involves the need to take appropriate action. The paper discusses the ecological method of using a biofilter, which is an installation for removing the odors generated in the process of solar drying of sewage sludge in a municipal wastewater treatment plant. This technology is used in many Polish dryers, it involves sludge drying in the summer. Direct air outlet from the solar dryer causes the emission of these compounds, which can be a serious problem, especially in high-capacity wastewater treatment plants. One of the most ecological methods, which consists in directing the exhaust air through water scrubbers to the biofilter, was used in the described object. The analyses were carried out on a real object, examining the ratio of biofilter filling under various atmospheric conditions to the reduction of odor compounds formed. This solution, according to research, is an effective method, but in such a system (solar dryer - biofilter), it is still not very popular.

**Keywords:** *odors; biofiltration; sewage sludge dryer; gas ammonia*





***Justyna Cader, Piotr Olczak, Renata Koneczna***

***Public support to photovoltaic in Poland on the example of the "Mój prąd"  
program***

In less than a decade, the photovoltaic sector has transformed into a global business worth 53 916 million USD in 2018, and is projected to reach 333 725 million USD by 2026. The pace and nature of its expansion around the world vary, including across the European Union (EU). Government subsidies and continuous innovation were among the factors contributing to its growth.

As a lack of funding is one of the most significant barriers to development of photovoltaics, in regions where private finance policies are lacking, public support can play an important role in promoting photovoltaics.

In Poland, there are many financial ways to intensify the construction of new renewable energy sources installations, among others: feed in tariff, grants. An example of photovoltaic grant support in Poland is the "Mój Prąd" [My Electricity] program created in 2019. This program, with a budget of 1 billion PLN, is intended for households that could apply for a grant to partially cover the purchase and assembly costs of solar installations with a capacity of 2–10 kWp.

To understand the extent to which EU funding has an impact on the development of photovoltaics various indicators were estimated for the amount of installed capacity under the program.

To select the method of calculating the unit quantity, correlation analysis for selected parameters has been used: number of inhabitants, area of households, Gross Domestic Product (GDP), Human Development Index (HDI), area of the voivodship and the level of education.

***Keywords:*** *photovoltaics; subsidies; "My electricity" program; renewable energy*



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### *The green deal implementation and sustainable development strategies in WWTPs*

Nowadays, the implementation of green, eco-friendly, clean, less energy and zero waste producing processes as well as technologies is realized with an increasing interest. In order to provide a sustainable economic development, environmentally friendly substances, novel and green technologies should be utilized. Therefore, in this paper Green Deal Implementation (GDI) and their principles are reviewed in relation to the conventional vs. alternative technologies for wastewater treatment plants (WWTPs). The paper shows the available green engineering and technical solutions, with the potential for further development of manufacturing technology towards heat and waste materials recovery as well as renewable energy sources, i.e. solar and/or photovoltaic panels, wind energy adapted in wastewater sector. Moreover increasing knowledge on alternative shortcut nitrification processes, new reaction pathways and their combination such as simultaneous use of autotrophic aerobic and anaerobic microbial ammonium conversions (i.e. anaerobic ammonium oxidation/anammox and/or deamination) provide the most cost-effective solutions, as could reduce the need for an organic C source and the aeration at least 40%, compared to the conventional nitrification-denitrification. This type of existing and newest promising processes or technologies might reach significant reduce of Green House Gas Emission and positive energy balance in WWTPs. Such innovations and more cleaner “green” technologies provided in future with attention to applications of mathematical modelling and computer simulations for optimisation of wastewater treatment and/or recovery, will probably lead to the success realization within the benefits to society, government, industry. This type of study need more research as they fit very well with the policy of the sustainable development in European Union (EU) and GDI for WWTPs.

**Keywords:** *WWTP; greenhouse gas; renewable energy sources; green technologies; computer simulations*

**Acknowledgments:** *This work was financially supported by National Science Centre as a result of the research projectno.2017/26/D/ST8/00967.*

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**Jarosław Gawdzik, Robert Kowalik, Agnieszka Grdulska**

*Analysis of the risk of accumulation of cadmium compounds in soils from  
sewage sludge from selected sewage treatment plants  
in Świętokrzyskie voivodeship*

Sewage sludge from wastewater treatment plants (WWTPs) has important soil-forming and fertilizing properties. However, it cannot always be used for this purpose. One of the main reasons why sludge cannot be used for natural purposes is its heavy metal content. The samples of sludge from 20 wastewater treatment plants in the Świętokrzyskie voivodeship have been analysed for cadmium accumulation and potential anthropogenic risk, especially in terms of mobility. Calculations were made for copper concentrations in sewage sludge from the analysed WWTPs and in arable soil from the measurement point in the places of potential use of analysed sewage sludge. The geoaccumulation index (GAI), potential environmental risk index (PERI), risk assessment code (RAC) and environmental risk factor were calculated. Next, mobility analysis was made and own indicator was proposed, conditioned by copper belonging to a given fraction. It was shown that a high level of potential risk indicators and geoaccumulation indicators does not necessarily disqualify the use of sewage sludge, provided that the cadmium content is contained in non-mobile fractions, which takes into account the proposed proprietary indicator.

**Keywords:** *sequential extraction; heavy metals; mobility of heavy metals; drinking water*

**Acknowledgments:** *Kielce University of Technology.*



***Seferhan Yilmaz, Kadir Alp***

## ***Sustainable Management of Sewage Sludge***

Treatment and disposal of sewage sludge is the important part of wastewater treatment. Sewage sludges are produced as a result of wastewater treatment processes and must be treated and disposed of. As sludge production increases with rapid population growth, the amount and disposal of sludge produced becomes a problem. In the selection of disposal alternative, the character of the sludge, long-term management objective, energy recovery, useful product obtaining feature, odor problems that may occur and the economy must be handled together. Therefore, the most cost-effective and sustainable long-term solution for sewage sludge management should be identified in the concept of circular economy. Landfilling, composting, thermal drying and incineration are most commonly applied treatment and disposal alternatives. This paper presents comparison of sludge management alternatives, including sustainable technologies such as bio-drying and solar drying, and evaluation in terms of greenhouse gases, odor generation and economics.

***Keywords:*** *sewage sludge; sustainable sludge management; circular economy; greenhouse gases; odor*



***Maria del Mar Cerrillo-Gonzalez<sup>1</sup>, João Brinco<sup>2</sup>, Maria Villen-Guzman<sup>1</sup>, Juan Manuel Paz-Garcia<sup>1</sup>***

### *Effect of pH on the formation of cobalt complexes during electrodialysis*

Cobalt is a metal that has experienced an increasing demand in the last decade, mainly for its use in the production of rechargeable batteries. Due to its economic importance and high supply-risk, cobalt was included in the list of Critical Raw Materials by the European Union. Hence, the European commission strategy is focused on the development of new mining technologies, substitution and recycling to secure its availability. In terms of recycling, lithium ion battery (LIB) wastes could be a source of cobalt and the development of new technologies to recover this metal should be addressed. The application of electrodialytic remediation (EDR) to LIB residues has been proposed as an innovative recycling process.

The objective of this work was studying the influence of the electric current in the formation of cobalt complex during electrodialysis. Experiments were carried out in a three compartment electrodialytic cell with an original Arduino based pH control system. Electrode compartments were separated from the central compartment (where cobalt solution is contained), by ionic exchange membranes. The electric current application allows: (1) the movement of the  $\text{Co}^{2+}$  to the catholyte, (2) the modification of the pH of anolyte and catholyte due to water electrolysis, (3) electrodeposition of metallic cobalt on the electrodes. The pH control of the catholyte promoted the formation of cobalt complexes improving the recovery of the metal. Experimental results showed that the pH in the catholyte compartment should be lower than 4, not only to avoid the  $\text{Co}(\text{OH})_2$  precipitation, but also to provide the cobalt electrodeposition which was in agreement with cobalt Pourbaix diagram.

***Keywords:*** cobalt; critical raw materials; electrodialysis; pH control

***Acknowledgments:*** This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 778045. The University of Malaga is acknowledged for the financial support in the postdoctoral fellowship of Villen-Guzman and the project PPIT.UMA.B5.2018/17. Cerrillo-Gonzalez acknowledges the FPU2018/04295 grant obtained from the Spanish Ministry of Education. Paz-Garcia acknowledges the financial support from the program "Proyectos I+D+i en el marco del Programa Operativo FEDER Andalucía 2014-2020", No. UMA18-FEDERJA-279.

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***Douae El Khachine, Khadija El Kharrim, Driss Belghyti***

***Study and follow-up of the performances of the wastewater treatment of the  
Tamuda bay Tetouan wastewater treatment plant***

The purpose of this work is to verify the effectiveness of the operation of the Tamuda wastewater treatment plant (WWTP). The treated water is reused during the company's production process. The physicochemical results obtained in the laboratory of the WWTP, over a period of three months, show that the wastewater has a neutral pH, and average concentrations of 0.83 mg/l of total nitrogen and 1 mg/l of ammonia. The determination of the pollution indicator parameters measured gives on average: BOD<sub>5</sub>=17 mg/l, COD=138 mg/l, and TSS =22 mg/l. The COD pollutant load at the entrance of the plant has increased from the month of January, from 172,506 kg/d to 219,506 kg/d. On the other hand, at the exit of the plant, the load has decreased up to 30%, which is explained by the high performance of the treatment carried out. The BOD<sub>5</sub> at the outlet shows a decreasing trend, with the majority of the measured values in the ranging from 1284 to 6203 kg/d. The TSS flows obtained are well in excess of the standards and are probably caused by sewage discharges and urban domestic discharges that are rich in colloidal material of mineral or organic origin.

***Keywords:*** wastewater; environment; COD; BOD<sub>5</sub>; pollutant loads; yield



***Dorota Andrzejewska-Górecka, Bartłomiej Macherzyński, Małgorzata Wszelaka-Rylik***

***Bioleaching of cadmium and zinc from a contaminated soil using bacteria from waste water sludge***

The aim of this work was to determine the influence of various variants of bioleaching on effectivity of releasing metal cadmium, zinc from contaminated soil using bacteria from activated sludge. The initial zinc and cadmium concentration in the soil was adequately - 957 mg/kg and 252 mg/kg dry-weight. The research was conducted in variants that considered different process factors such as mixing and aeration. The research was conducted in 3 variants of bioleaching – mixing and aerating, only mixing, only aerating and in 2 control variants – aerating and mixing. The variants were conducted in the temperature of 24°C. The bioleaching culture consisted of activated sludge and distilled water in 1:2 ratio and 1% of dusty sulfur. After 7 and 14 days of the process the markings were made: the index of sulfur oxidizing bacteria, metals content, sulfate concentration, pH. Determination of the elemental composition was performed by ICP-OES plasma excitation spectrometry. The best result of bioleaching for both metals were achieved in variants with mixing and aerating. For zinc the efficiency of the bioleaching was 66% after 14 days of leading the process and cadmium it was 99% after 7 days of leading the process. In case of cadmium leading the process longer had negative impact for the bioleaching. The bacteria activity, sulfate concentration and pH measurement correspond to effectiveness metals removal in bioleaching all variants.

***Keywords:*** *bioleaching; metals; cadmium; zinc; contaminated soil*

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**Shahnawaz Dahri, Ashfaque Ahmed Pathan**

### *Treatment of wastewater through high-rate trickling filter*

In many parts of the world, health problems and diseases have often been caused by discharging untreated or inadequately treated wastewater. Such discharges are called water pollution, which has a serious impact on all living creatures, and can negatively affect the use of water for drinking, household needs, recreation, fishing, transportation, and commerce. Treatment technologies include physical, biological, and chemical methods. A trickling filter is an aerobic treatment system utilizing microorganisms attached to a media to remove organic matter from wastewater that passes over, around, through, or by the media. The trickling filter is a three phase system. The aim of this study is to investigate the performance of a high rate trickling filter to treat wastewater. Physical as well as chemical parameters such as pH, total suspended solids, total dissolved solids, chloride concentration, turbidity, and BOD<sub>5</sub> of treated wastewater at high flow rate were observed. Samples for testing have been taken out at three various points i.e. influents, effluents and secondary clarifier tank (after sedimentation). The pH value results from 8 to 8.6. The trickling filter is 74.7% efficient in removing turbidity at high flow rate. The efficiency of trickling filter at high flow rate in removing TSS was observed 98%. At the start of the testing, there was not found immense change into TDS. After getting system mature, study observed sudden decrease into TDS of treated wastewater. BOD<sub>5</sub> which was a critical parameter for the evaluation of system efficiency. The removal efficiency of BOD<sub>5</sub> at high-rate flow in treating the wastewater is 40 to 60%.

**Keywords:** pH; BOD; TDS; TSS; COD

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**Marzena Smol**

*Market ready technology for P-recovery from municipal wastewater –  
assumptions of PhosForce EIT RMs Materials project*

The European Commission (EC) underlines that the implementation of the Circular Economy (CE) model requires development of innovations – technological, environmental, political, law and social. In the last years, more and more recommendations and restrictions have been proposed for the recovery of biogenic raw materials from waste generated in municipal wastewater treatment plants (WWTPs), as the way towards CE in the waste and sewage sector. One of the possibility is recovery of phosphorus (P) from sewage and sewage sludges in municipal WWTPs, for which restrictions on P recovery have been already implemented in Germany and Switzerland. Paper presents the main results of the project “Market ready technologies for P-recovery from municipal wastewater” (PhosForce) which is realised by the consortium of the Knowledge Triangle of partners from Germany, Poland, France, Portugal, Belgium and Denmark, under the financial support of the EIT Raw Materials (2018-2020). The main goal of the project was to develop an innovative technology for the recovery of P from sewage - in the form of struvite crystals from wastewater produced in municipal WWTPs. The demonstration plan was built in WWTP Schönebeck, Germany. The obtained fertilizer products meets the Polish & European standards for the commercial fertilizer products.

**Keywords:** wastewater treatment plant (WWTP); sewage sludge; recovery; phosphorus (P)

**Acknowledgments:** Research carried out under the project PhosForce (no. 17088) financed by EIT Raw Materials under Horizon 2020.

Supported by



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This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation



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### *Analysis and multi-criteria optimization of the electricity production process in hydropower plants*

Energy and climate policy of the European Union is strengthening, combined with the volatility of prices of CO<sub>2</sub> emission allowances, set the direction for the development of the energy sector. The main research issue is to identify factors and model the profitability of generation assets and to prepare options for profitable development of hydropower plants.

The research covers the practical aspects of running a business and the problems faced by the owner of 34 hydropower plants. The research in particular covers aspects of:

- potential for integration with other renewable energy technologies within the infrastructure of hydropower plants;
- environmental and climate issues;
- water and flood management;
- impact of regulation and the consequences of liquidating support mechanisms for hydropower plants;
- use of a virtual power plant in the management of hydropower production.

The volatility of cash flows as a result of changes in electricity prices and certificates of origin for electricity generated from renewable energy sources forces the search for ways to improve efficiency and identify opportunities for managing energy production in order to maintain the profitability of hydropower plants. In addition, the economic environment, the changing climate and natural situation as well as regulatory impact force the company's reactions.

The integration of various renewable energy sources with energy generation in hydroelectric power plants is one of the possible development directions and using the potential of information technology.

**Keywords:** *multi-criteria optimization; electricity production; hydropower plants*

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**Krzysztof Chyła, Krzysztof Gaska, Zygmunt Niski**

### *Comparative analysis of selected methods of joining sheets of aluminium alloys*

The paper contains general information on selected methods of joining aluminium sheets. The main emphasis was placed on testing the strength of the sheet connection using the friction stir welding (FSW) method. Description of the static tensile test, aluminium alloys used in the aviation and defence industries.

In the practical part of the research, the aluminium alloy 2024 - T3 was used, most often used in the production of aircraft fuselage covers. The test consisted in welding two pieces of overlapping sheet metal using the FSW method, using various process parameters. The thickness of the sheet metal used was 1 mm. Parameters of the presented tool: cylindrical tool pin with a diameter of 4 mm, cylindrical tool flange with a diameter of 10 mm, pin height 1.9 mm, head angle 3% conical contact surface of the flange to the welded plane with a concave angle of 100.

After the welding was completed, a test of breaking the samples was carried out on a testing machine. Based on the results, appropriate process parameters were selected, at which the weld showed the greatest strength. The result of the implementation of the FSW process should be an increase in the efficiency of joining sheets. It should also reduce the energy consumption of the process, which will translate into lower production costs of the final product.

**Keywords:** *aluminium; sheet; efficiency; friction stir welding (FSW)*



**Agata Rosińska, Klaudia Rakocz**

*The effect of ozonation on changes in the content of biodegradable organic matter in water intended for consumption*

The substances that have the greatest impact on the development and growth of microorganisms in water are biodegradable dissolved organic carbon (BDOC). The analysis of biodegradable forms of organic carbon should consist not only of the determination of BDOC but also of assimilable organic carbon (AOC). The aim of the research was to evaluate changes in the content of BDOC and AOC after the ozone disinfection process in groundwater and surface water from a dam reservoir, from which the waterworks company collects and treats water. Ozone doses were equal to 1.6, 5 and 10 mg/L. In the waters before and after the disinfection processes, the content of selected forms of organic carbon was determined, i.e. total organic carbon (TOC), dissolved organic carbon (DOC), BDOC and AOC. The research showed that the applied doses and contact times of disinfectant with water influence significant changes in the content of BDOC and AOC in the analysed water. By extending the contact time of ozone with the tested water up to 15 minutes, at the dose of 1.6 mg/L, the BDOC content increased by 31%, and at the dose of 10 mg/L, the BDOC content increased by 113%. It was demonstrated that after applying ozone doses selected for the tests and with increasing contact time with ozone, the concentration of AOC in the analysed water increased. The obtained research results will enable the selection of appropriate ozonation parameters in order to prevent secondary growth of microorganisms in the distribution system.

**Keywords:** *biodegradable dissolved organic carbon; assimilable organic carbon; groundwater; surface water*

**Acknowledgments:** *This research was funded by the Polish Ministry of Science and Higher Education, grant number BS/PB-400-301/19, BS/MN- 402-301/13 and BS/MN 402-301/18.*



***Gabriela Rutkowska, Marek Chalecki***

***Fly ash from thermal conversion of sludge as a cement substitute in concrete manufacturing***

Striving for reduction of production costs and constraints on natural resources cause that use of waste materials as substitutes of traditional raw materials becomes increasingly important. Dynamical development of sewerage systems and sewage treatment plants, observed over the recent years, leads to increase of mass of the produced sewage sludge. According to the Statistics Poland (GUS) data, the municipal sewage treatment plants in the year 2019 produced 574 643 Mg of sludge. According to the Waste Law, the municipal sewage sludge can be used if it is properly stabilized, e.g. through a thermal processing. This process results in significant quantities of fly ash which must be properly utilized. The paper presents results of investigations of influence of partial replacement of cement by the fly ash from sewage sludge on concrete parameters. It was designed a C20/25 class concrete mix, based on the Portland cement CEM I 42.5R with various ash content, equal to 0 - 25% of the cement mass. Physical and chemical properties of the ash as well as frost resistance and the compressive strength of the concrete after 28, 56 and 365 days of curing were investigated. Considering the chemical composition of the used ash, it was observed that lower concentration of  $P_2O_5$ , CaO,  $SiO_2$  and  $Al_2O_3$  as well as higher concentration of  $SiO_2$ ,  $Al_2O_3$  and  $Fe_2O_3$  increase strength of the investigated concretes. The concrete modified in 20% by the fly ash reached its average compressive strength equal to 40.7 MPa after 28 days of curing, 42.83 MPa after 56 days and 46.5 MPa after 365 days. Samples modified in 15% by the sewage sludge fly ash and subjected to 150 freeze-thaw cycles can be classified as having frost resistance level F150. The obtained results of investigations confirm the possibility of application of fly ash wastes as a cement substitute in the concrete manufacturing. If a predefined quantity of cement is replaced by the fly ash, then one can obtain cement composite with good strength parameters.

***Keywords:*** concrete; cement; fly ash; properties

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***Application of shrimp waste for synthesis of polyurethane materials with  
potential use in sorption of oil spills***

Shrimp waste is one of the seafood production wastes in the food industry. Currently, its proper development is economically unfavourable. It is most often used as part of the fish meal added to feed. Bearing in mind the pursuit of a circular economy, it was proposed to use Northern prawn shells to obtain chitosan, which was then used to the polyurethane modification.

In transshipment ports, oil micro-spills often occur into the waters of the gulf and, consequently, into seas and oceans. Systematic chemical and petroleum water pollution may pose a threat to flora and fauna. Several literature reports confirm that chitosan-based polyurethanes can be an effective material for metal ion adsorption, while polyurethane foams are used as oil spill absorbers.

In this study, chitosan, which was obtained from shrimp shells, was used to synthesize of flexible polyurethane-chitosan foams with different chitosan concentrations. Selected physico-chemical properties and sorption properties in relation to oil and water sorption of these materials were determined. It was found that the amount of added chitosan and the method of its addition into the foam were affected their morphology of the foams, their hardness, density, as well as thermal and sorption properties. The conducted research made it possible to demonstrate the use of these materials in the processes of water purification from the mentioned micropollutants. In order to evaluate the advantages of the obtained foams as an innovative product and their environmental impact, a SWOT (strengths, weaknesses, opportunities, and threats) analysis was performed.

***Keywords:*** *shrimp waste; chitosan; polyurethane; oil sorption; SWOT analysis*

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***Olena Dan***

### *Sulphides removal from slag infiltrate with layered double hydroxides*

Special place among a wide range of pollution sources of water bodies is occupied by industrial wastewater as they contain a huge amount of harmful substances. This is especially important in the case of industrial plants which are not equipped with a closed water circulation systems. Sulphides are in such substances list and can get into water bodies directly with industrial wastewater. Slag infiltrate is formed as a result of contact of metallurgical slag with water. Sulphides concentrations in the slag infiltrate can be around 500 mg/l. Sorption methods are perspective for wastewater treatment from sulphur compounds. Method based on the using of Mg/(Mg + Al) layered double hydroxides (LDHs) with 0.72 mol/mol Mg and Al molar ratio as sorbents is proposed for the removal of sulphides from the slag infiltrate. Prospects for their using for purifying slag infiltrate from sulphides as well as kinetics of sulphides removal in the presence of proposed sorbents using model solutions and slag infiltrate samples are presented. It was found that the effectiveness of using Mg / (Mg + Al) LDHs with 0.72 mol/mol molar ratio of Mg and Al for the slag infiltrate treatment from sulphides is over 40% and for model solutions is over 90%.

***Keywords:*** *infiltrate; LDHs; metallurgy; slag; sulphides*



**Piotr Bargiel**

### *Coke wastewater treatment in the sorption process*

The dynamically developing coke production in Poland requires the use of effective wastewater treatment methods. Due to the content of many chemical compounds, coke wastewater treatment poses a number of problems and therefore its treatment is most often carried out in several stages. Currently, efforts are being made to implement modern methods of wastewater treatment in order to obtain treated wastewater that will comply with the requirements set out in the legislation and at the same time be environmental friendly. Adsorption processes are currently the most popular among the techniques used for wastewater treatment. This type of process uses very wide range of adsorbents, both of inorganic origin, such as: porous glasses, zeolites, and organic materials, including active carbons, dusts and biochar, as well as, to a lesser extent, activated carbon fibres, carbon blacks carbon and ordered mesoporous carbons. Adsorbents are the most often used to adsorb pollutants from wastewater in dusty and granular form. For their production, charcoal, hard coal, lignite, anthracite, peat, fruit seeds, nut shells, etc. are used.

The aim of the study was to characterize the sorption properties of selected sorbents and to assess the possibility of their use to support the process of cleaning coke wastewater from ammonium nitrogen, phenol and TOC. The scope of the work included the research on the sorption properties of selected sorbents (coal dust, coke dust, biochar), physical and chemical tests of coke wastewater and tests aimed at determining the dose of adsorbents and the time needed to establish the process equilibrium state. Tests were carried out and the obtained results of the dose and contact time influence on the effectiveness of pollutant removal were analysed.

**Keywords:** *coke oven wastewater; wastewater treatment; coking plant; sorption; biochar*





**Ewa Okoniewska**

### *Removal of selected dyes on activated carbons*

Dyes are widely used in various industries, e.g. paper, food, plastics and fibre production. The produced wastewater in these sectors has a specific character. Organic substances found in sewage and introduced into natural water reservoirs have a toxic effect on living organisms, cause increased chemical and biological oxygen demand. Some dyes even in very low concentrations cause very intense colouring.

In order to remove dyes from wastewater, such methods as flotation, oxidation, ozone, filtration or coagulation with metal compounds are used. Unfortunately, when using these methods very large amounts of sludge are formed, which is another environmental problem. Therefore, one of the methods by which it is possible to remove dyes effectively from waste water without generating a large amount of waste is adsorption on active carbon.

Adsorption methods in the treatment of wastewater from the dye industry are of particular importance due to their high efficiency, ability to work in a relatively wide range of concentrations, availability. The most common adsorbent is activated carbon, which has a high adsorption capacity in relation to many organic compounds.

The aim of this work was to determine the influence of filtration speed and type of active carbon on the effectiveness of removal of selected cationic (anilian golden yellow) and anionic (tartrazine) dyes from aqueous solutions.

**Keywords:** *adsorption; activated carbon; dyes*

**Acknowledgments:** *The scientific research was funded by the statue subvention of Czestochowa University of Technology, Faculty of Infrastructure and Environment.*



**Monika Partyka**

### *Water quality monitoring using ICP-MS*

Human life quality depends on the state of the environment – air, soil and water pollution. There are many sources of water quality criteria and standards and continuous monitoring of the environment is necessary, for monitoring purposes different analytical techniques are used.

One of the indicators that define water quality is the content of elements. The concentration of the elements should be routinely monitored both in drinking water and surface and runoff water. Inductively coupled plasma mass spectrometry (ICP-MS) is an analytical technique, that can be used to measure elements in water. ICP-MS enables the simultaneous determination of many elements, which significantly affects the efficiency and cost reduction of tests. It is also possible to achieve low limits of quantification and reduce the sample preparation step. The advantages of the ICP-MS mean that it can be classified as a technique to the so-called green analytical chemistry.

The paper presents the possibility of ICP-MS – linked to the applicable law – used to determination of elements in water samples. Appropriately selected methods allow obtaining a wide range of linearity and appropriate repeatability of measurements (not exceeding the value of 10% relative standard deviation), as well as recovery in the range 80 - 120%, depending on the analysed element.

**Keywords:** *environment; water analysis; monitoring; quality; green analytical chemistry*



***Marek Dohojda, Joanna Witkowska-Dobrev, Olga Szlachetka, Krzysztof Wiśniewski***

***Environmental problems of use of agricultural objects in the aspect of exposure to aggressive media***

Aggressive working environment of a building construction is one of the crucial threats for concrete durability. It is especially essential for livestock buildings. Concrete is a highly alkaline material (pH 11,2), therefore the presence of organic acids (acetic, butyric, lactic) from agricultural sewages makes a threat for the concrete and environment.

The investigations were aimed on a simulation of action of highly concentrated organic acids which can originate e.g. from a liquid manure or ensilage and damage concrete elements of livestock buildings. Cubic samples of the ordinary concrete were immersed in 10% acetic acid for 270 days. Then, it was determined compressive strength and mass decrement of the samples as well as, basing on SEM images and 3D-profilograph – surface roughness and depth of changes evoked in the structure of the samples by penetrating acid. The results were compared to those for a control sample (not subjected to the action of aggressive medium) as well as for samples placed in a neutral and alkaline environment.

The microscopic imaging integrated with strength tests enabled evaluation of the concrete damage process resulting from the acidic corrosion. The compressive strength of the samples stored in the acidic environment was 39% lower than that of the control sample whereas of those stored in the alkaline environment – 37.5% lower. Conclusions from these investigations can be of innovative importance in the aspect of preparing environmental impact reports, necessary for obtaining permission for construction works and use of livestock buildings, and afterward impact of these buildings on the environment and surface and underground water resources.

***Keywords:*** *livestock buildings; concrete; acidic corrosion; environmental protection; microscopic analysis*

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**Norbert Dąbkowski<sup>1</sup>, Karolina Rytel<sup>2</sup>**

*Livestock buildings on an organic farm - existing material and structural solutions*

The papers presents the results of direct research on livestock buildings and their modernization in selected ecological farms in eastern part of Mazowieckie Voivodeship, Poland. The following regions of the Mazowieckie Voivodeship were selected as the research areas: Sokołów Podlaski and Węgrów. A total of livestock buildings in 14 farms on 33 visited ones were examined. The research was conducted based on a site visit and discussions with the owners. The research goal that was attempted was to find a relationship between ecological animal husbandry and a building substance (livestock buildings). For this purpose, the solutions related to ecological construction known from the literature were presented and compared with the existing solutions for livestock buildings in the researched farms. The research showed that there are no links between the organic farm and the livestock buildings there.

**Keywords:** *livestock building; ecological farm*

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**Wojciech Derej**

*The European Union waste management in the context of a European Green Deal implementation*

One of the fundamental issues to be considered in the modern economic development of the European Union (EU) is the environmental aspect. The EU in recent years provided the strategies for economic development that take into account environmental concerns. These strategies assume that the EU countries will meet a number of environmental standards. Currently, these strategies were indicated as the part of the European Green Deal. One of the key factor that determines the implementation of this growth strategy is the proper waste management.

The aim of the study is to present the determinants of waste management in EU countries against the background of environmental standards in this area. These standards concern the way of waste management, including recycling levels. Statistical information shows that waste management in the EU is on an increasingly higher level, but individual countries show significant differences in this aspect. One of the main factors supporting effective waste management is the development of modern technologies in this area, which can often be called ecological innovations.

The analysis undertaken in the study shows that a certain regularity can be observed, according to which countries with a high level of innovation represent a high level of waste management (including recycling). This proves the legitimacy of activating ecological innovation, and then their implementation in the form of ecological investments, as elements contributing to the Green Deal implementation.

**Keywords:** *Green Deal; circular economy; ecological innovations; waste management*



**Wojciech Derej**

*The European Green Deal implementation possibilities in the context of economic development, in the environmental aspect*

In the modern economic development of the European Union (EU), environmental issues are becoming increasingly important. In recent years, a number of EU plans and programmes have been developed to define economic development strategies, particularly with regard to environmental aspects. The strategies assume the environmental standards related to existing development concepts are to be respected by the EU countries. One of the latest concepts of this kind is the vision of European Green Deal.

The aim of the study is to present the European Green Deal as the kind of evolutionary effect regarding existing concepts of economic development. Therefore, the study also shows the main ideas of the European Union economic development in the context of environmental conditions, such as sustainable development, circular economy, green economy or green growth.

In addition, the study shows the implementation possibilities of the described concepts of economic development and, as a result, Green Deal. One of the basic factors in this area is the development of modern technological solutions of an innovative nature, called ecological innovations. The development of such innovations and their practical application in the form of green investments contributes to the implementation of the economic development ideas.

Another important factor in the implementation of the development concepts is the creation of the so-called "green jobs" and "green skills". With the constant raising of social "ecological awareness", they support the implementation of the economic development vision with respect for the natural environment, thanks to activities carried out within the framework of professional activity taking into account, the environmental aspect.

The development of innovations and ecological investments, as well as the creation of green jobs and green skills, creates an opportunity for the implementation of the presented development concepts, aimed at achieving the Green Deal, enabling the preservation of natural capital, as well as improving the quality of life.

**Keywords:** *Green Deal; green economy; circular economy; eco-innovations; green jobs*



**Matylda Gacek**

## *Natural bioclimatic architecture in the context of the climate crisis - the potential of industrial hemp in construction*

In the context of today deepening climate crisis, it is necessary to minimize the negative impact on the climate of all sectors of the economy, including the construction and architecture sectors. It is estimated that the given sector significantly uses water and raw materials. At the same time, it is responsible for nearly 40% of global CO<sub>2</sub> emissions to the Earth's atmosphere, 11% of which are the result of the production of building materials.

In order to reduce CO<sub>2</sub> emissions and the continuous degradation of environmental resources, it is worth defining the principles of bioclimatic architecture in relation to the current and future climate. It is essential to consider and use the local climatic characteristics of the area, as well as to use building materials with a minimized impact on the environment. The research is focused on the warm temperate climate zone (Poland).

The presented assumptions are fully met by natural architecture. Based primarily on renewable and rapidly growing construction materials of natural origin and low-energy construction technologies.

Hemp concrete (hempcrete) can become an important alternative to construction in a warm temperate climate zone, essentially reducing the harmful effects on the environment and climate. The main goal of the work is to determine the significant potential of hemp concrete in Poland on a large scale.

Hempcrete has also been analyzed within the framework of the circular economy concept. Hemp, which in its life cycle is: raw material, product, construction material, building, and finally biodegradable construction waste, represent the circulation of matter in the environment without generating losses and waste for it.

To sum up, technologies with the use of industrial hemp, including hempcrete, due to their properties, are in many respects a preferable material for use in architecture in the context of current and future climate changes, representing a significant potential in shaping future forms of housing.

**Keywords:** *bioclimatic architecture; natural architecture; industrial hemp; hemp concrete; hempcrete; climate crisis*

**Acknowledgments:** *IPCC, 2019. Special report. Climate Change and Land <<https://www.ipcc.ch/srccl/>>. | Stanwix W., Sparrow A., 2016. Podręcznik budowania z konopi. Łódź: Fundacja Cohabitat. | Couvelas A., 2019. Bioclimatic building design theory and application. The 1st International Conference on Optimization-Driven Architectural Design (OPTARCH 2019).*

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**Jagoda Worek, Maciej Słoboda, Anna Białas, Agnieszka Włodyka-Bergier, Katarzyna Styszko**

*Photodegradation of selected pharmaceuticals with the use of TiO<sub>2</sub> and UV-C radiation*

The amount of pharmaceutical substances used is constantly increasing. The presence of medications and their metabolites in the environment has serious consequences for living organisms. These compounds are persistent, toxic and bioaccumulate. Most often they get into the environment along with unnecessary metabolic products, which are discharged with sewage from households or hospitals. Such compounds are among the new contaminants of increasing concern (CECs) of which diclofenac and carbamazepine are typical representatives of the pharmaceutical sector. Traditional methods of wastewater treatment are not able to significantly degrade pharmaceuticals and their derivatives, therefore other solutions are being sought to eliminate them.

The aim of the research was to assess the effect of titanium (IV) oxide and UV-C radiation on the degradation degree of carbamazepine and diclofenac. A solution with a specific concentration of CBZ and DCF was exposed to one-hour irradiation, in one variant of the study it was carried out with the addition of the catalyst, and in the other without. During this time, samples were taken for chromatographic analysis at designated intervals. Diclofenac degradation was 100% in both cases and about 80% of carbamazepine.

**Keywords:** photocatalytic degradation; pharmaceuticals; diclofenac; carbamazepine; titanium dioxide

**Acknowledgments:** Research financed by Research Subsidy AGH 16.16.210.476.





**Wioleta Bolesta<sup>1,3</sup>, Marcin Głodniok<sup>2</sup>, Katarzyna Styszko<sup>1</sup>, Michał Pieczonka<sup>3</sup>**

### *Possibilities of using sewage sludge in terms of the presence of micropollutants*

The formation of sewage sludge in the wastewater treatment process is an inevitable component of this process. The resulting waste must be managed, e.g. in land reclamation or as the organic and mineral fertilizers based on sewage sludge. In every of these cases, the qualitative and quantitative composition of the sludge should be considered.

Previous studies of sewage sludge clearly indicated the presence of micropollutants in raw sewage, such as residues of pharmaceuticals, personal care products. This broad group of compounds differs in terms of physicochemical properties and the ability to adsorb to sediments. For this reason, the effectiveness of their removal by the activated sludge method and their further fate are also different. Some of them are significantly reduced in the treatment process (e.g. ketoprofen). There is a large group of hydrophilic compounds that are only slightly reduced and thus leave the treatment plant together with the treated sewage (e.g. estrone). On the other hand, substances characterized by high adsorption to sediment, such as active ingredients of hormonal agents, bind with it, which in turn may affect the possibility of its safe use.

This paper deals with the methods of analysing micropollutants and their possible reduction. Taking into account the research carried out so far, it should be stated that the results of these analyses differ and depend on the type of the tested substance, its concentration and the method used.

**Keywords:** *sewage sludge; emerging contaminants; pharmaceuticals; sewage sludge management*

**Acknowledgments:** *This research was partially financed by the AGH UST grant 16.16.210.476 subsidy of the Ministry of Science and Higher Education.*

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***Justyna Koc-Jurczyk, Łukasz Jurczyk***

### *Sustainable management of sewage sludge as a tool for the circular economy*

Sludge generated in municipal wastewater treatment plant accounts for about 3% of the volume of wastewater flowing through, but the expenses for its management can account for up to half of the operational costs. The quantitative and qualitative parameters of sludge are influenced, among others, by local demographic characteristics, types of wastewater flowing into the installation and their composition, the concentration of contamination indicators in raw wastewater and treatment technology. The main purpose of the sludge recovery strategy is the maximal usage of their agronomic properties and fertilizing potential, i.e. the organic matter content and such nutrients as nitrogen, phosphorus or microelements, whilst ensuring environmental safety for soil and water. In Poland, 586 thousand Mg of wastewater sludge dry mass is produced annually, and its landfilling is not allowed since 2016. Among the management methods, the most common is agricultural usage (116 thousand Mg per year), then thermal utilization (101.1 thousand Mg per year). A significant part is also utilized for reclamation of degraded land. However, the most important trend promoted by the European Union, in line with the principles of the circular economy, is the recovery of valuable elements from wastewater, such as phosphorus derived from households detergents and industry. In Poland, phosphorus is reclaimed from ashes resulting from sludge incineration and forwarded for production of fertilizers. In this paper the review of the possibilities of natural utilisation of sewage sludge in Poland in accordance with the current national and regional regulations is presented.

***Keywords:*** *municipal sewage sludge; sludge management*



***Łukasz Jurczyk, Justyna Koc-Jurczyk***

*The influence of temperature on the efficiency of landfill leachate treatment in classic and hybrid SBRs*

Research on the treatment of leachate from municipal landfill was carried out in a six sequential batch reactors (SBRs) and their hybrid version (HSBR) equipped with biomass carriers made of PU foam cuboids of 30ppi porosity. The reactors were operated at 20, 30 and 40°C. The operational cycle lasted 24 hours, while hydraulic retention time (HRT) was set at 48 hours. In the reactors alternately aerobic ( $DO < 1$  mg/L) and anaerobic conditions were maintained. Raw leachate was characterized by COD concentration of 3278 mg/L, 672 mg/L of total nitrogen, including 630 mg/L of ammonia. Neither nitrate nor nitrite nitrogen was found in the leachate drained from the landfill. The nitrogen loading rate (NLR) was relatively low in all reactors and amounted to 0.315 kg/ m<sup>3</sup>/d, organic compounds loading rate (OLR) – 1.63 kg/m<sup>3</sup>/d. The highest removal efficiency of both organics and nitrogen compounds was achieved in HSBR operating at 40°C, and was 78% and 80.8%, respectively. Quantitative analyses of the amoA gene in suspended sludge were also conducted during the stabilization of the outflows. It was found that the number of gene copies in the active volume of all the reactors was successively decreasing during the first 3 weeks of operation. Then, the microbial communities starting to adapt to the technological conditions and composition of leachate, as it was shown by the increase in the number of amoA copies, regardless of the treatment temperature and the presence of fill in the reactors. This data was also supported by biodiversity analysis using three RAPD primers.

***Keywords:*** SBR; HSBR; nitrogen; landfill leachate; amoA



***Ewa Hołota, Sylwia Terpiłowska, Artur Polit***

### *Analysis of selected indoor air parameters in a teaching room*

The paper presents an analysis of physical and qualitative parameters of air such as temperature, relative humidity and CO<sub>2</sub> concentration, as well as microbiological analysis of air in the teaching room during classes. Measurements were made in a computer room with nine computer stations. They were conducted in two series. The first one started after the room was ventilated intensively to temperature 20.2°C, whereas the second was preceded by heating the room to a temperature of temperature 23.1°C. The measurements of the physical and qualitative parameters of the air were carried out using the TESTO 480 device, which was placed at the height of students' heads. Microbiological analyses were carried out using the sedimentation method and placing Petri dishes with nutrient agar and Sabouraud's medium at a distance of 1.5 meters from the fan coil and at the computer. The dishes were incubated at the temperature of 20°C and 37°C.

As a result of the analyses, the first series of measurements showed an increase in temperature by +1.7°C and an increase in carbon dioxide concentration to the level of 723 ppm. Air humidity ranged from 39.9% to 44.1%. In the second series the temperature increased by +0.9°C, the carbon dioxide concentration increased to the level of 914 ppm, while the air humidity ranged from 29.8% to 32.4%. The conducted microbiological analyses showed that after incubation at 37°C G+ and G- cocci bacteria were observed, while no fungal growth was observed.

***Keywords:*** *indoor air; carbon dioxide concentration; humidity; microorganisms*



***Sylwia Terpiłowska, Ewa Hołota, Magdalena Pliszka***

### *Microbiologic air pollution around municipal waste containers*

Waste collecting is a transitional stage of waste management. Although it is only a short-term stage, it can pose a problem for the inhabitants of urban estates. It may cause a sanitary risk resulting from the improper hygienic condition of the containers, which cause the growth of microorganisms.

The aim of the study was to assess microbiological air pollution in the vicinity of selected municipal waste containers in Stalowa Wola. Microbiological air analyses were carried out in the winter and summer. The samples were taken at the following points: the first was next to the containers, the second was located 10 m from the entrance to the containers and the third about 30 m from the containers.

The tests were carried out with the use of the sedimentation method on nutrient agar and Sabouraud's medium. The plates were incubated at 20°C and 37°C. After incubation, the number of microorganisms such as bacteria and fungi was determined. Additionally, the Gram staining of microorganisms was performed. In winter, at all sampling points, no bacterial growth was observed at 37°C, whereas at 20°C the growth of G- bacilli bacteria was observed. Additionally, at point 1 G+ bacilli bacteria were observed, while at point 2 yeasts. In the summer, at 20°C, at point 1 G+ bacilli, cocci bacteria and yeast were observed, while at point 2 G- cocci bacteria. Moreover, at 37°C, at point 1 G+ cocci bacteria were observed, at point 2 G+ and G- bacilli bacteria, and at point 3 G- cocci and bacilli bacteria were observed.

***Keywords:*** *microorganisms; air; municipal refuse*



***Sylvia Terpiłowska, Robert Stachyra, Ewa Hołota, Dawid Maryniak***

### *Selected physico-chemical and microbiological parameters of water from the San River*

Water is the natural living environment for many microorganisms. Their presence in water may make it unusable for animals and humans. To maintain a proper microbiological condition of water is a serious ecological issue. The main source of water microbiological contamination is municipal sewage.

The aim of the study was to determine the microbiological and physico-chemical composition of water taken from the San River depending on the season. Water samples were taken in the winter and in the summer. The basic physico-chemical parameters of water samples were determined by: pH using a pH electrode, conductivity and TDS (total dissolved solids) using a conductometric device, and turbidity using an infrared turbidimeter. In addition, water samples were diluted in the concentration range from  $10^{-1}$  to  $10^{-6}$  and inoculated by the surface plating method. The plates were incubated at temperatures 20°C and 37°C. After incubation, the number of microorganisms such as bacteria and fungi was determined. Additionally, the Gram staining of microorganisms was performed.

The results obtained of pH, conductivity, TDS and turbidity were within the expected parameters of natural surface waters. Microbiological analyses of samples taken in the winter and incubated at the temperature of 20°C showed the growth of G- cocci and bacilli bacteria and G+ bacilli bacteria, while at 37°C G- and G+ bacilli bacteria growth was observed. In the summer, no growth of microorganisms was noticed at the temperature of 20°C, but at 37°C G- cocci bacteria in chains were observed. However, growth of fungi was not observed.

***Keywords:*** *microorganisms; water; San River*



**Józef Ciula<sup>1</sup>, Agnieszka Generowicz<sup>2</sup>, Krzysztof Gaska<sup>3</sup>**

*Modeling the migration of anthropogenic pollutants from an active municipal waste landfill in groundwater*

Waste storage is one of the methods of its neutralization. This facility requires systematic monitoring of its impact on individual components of the environment, especially on underground and surface waters. It is related to the leachate which, due to its composition, poses a threat to water in the event of its release into the environment. It results in the release of hazardous substances contained in the leachate to the aquifer. Modelling of the migration of pollutants in this direction and the pace of its occurrence was performed in the paper. For this purpose, a conceptual hydrodynamic model of an aquifer was built in the Visual ModFlow Pro program, which is a spatial two-layer model. The chloride ion was adopted as the indicator determining the rate of migration of pollutants. The results of the calculations and modelling of the migration of pollutants in soil and water conditions showed that it is practically impossible for pollutants to get into the aquifer, as the sandy loam layer provides sufficient insulation, which practically limits the possibility of leachate infiltration from the landfill. The potential for the migration of pollutants to groundwater appears only in the event of a breach - damage to the insulating layer. In such a case, vertical infiltration will take place in the aeration zone for a relatively long period, while the migration of pollutants in the saturation (irrigated) zone will take place at a relatively high speed.

**Keywords:** *landfill; leachate; environmental monitoring; modelling; migration of pollutants*

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***Justyna Dziecioł, Wojciech Sas***

***The impact of chemical stabilization on combustion slag in the context of sustainable development policy for the Earth Construction sector***

Sustainability is one of the European Union's policy aims, including those concerning mineral resources management such as aggregates. The objectives and priorities related to raw materials and resources concern their life cycle. In the case of the construction sector, these activities are focused on the recycling of construction, demolition, and post-industrial waste. Currently, much of the environmental information needed to interpret, forecast or design sustainability solutions in industrial systems come from Life Cycle Assessment. The application of recycled aggregates in the civil engineering sector is important in terms of environmental impact and should be quantified. The production of recycled aggregates increases with the development of the construction industry and their landfill and management are becoming increasingly difficult.

The paper focuses on the environmental impact and single-axis compression strength of chemically stabilized combustion slag (CS). The combustion slag is one of the waste from the production of thermal energy, which is produced in the process of burning hard coal. The combustion slag fulfils the requirements for aggregates used in road construction, sports and recreation facilities, and for land levelling. Except for carbon in CS, the elements with the highest percentage are aluminium and silicon. Their occurrence proves the ability to create alkaline silicate bonds. This is important for the chemical stabilization of this aggregate, has an impact on the leaching of heavy metals from it and affects the strength and life of the aggregate built into the construction infrastructure.

***Keywords:*** *sustainability development; life cycle assessment; combustion slag; chemical stabilization; single-axis compression strength*

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***Tomasz Golda<sup>1</sup>, Krzysztof Gaska<sup>1</sup>, Agnieszka Generowicz<sup>2</sup>, Józef Ciula<sup>3</sup>***

***Optimisation of the water losses in the water supply network with the use of an intelligent zone analysis algorithm***

The paper describes the process and the effects of the implementation of RPWiK Tychy S.A. expert module for water network operation analysis, operating 1500 km of water supply network in 9 administrative areas.

The company has been working for four years according to the concept of dividing the water supply system into DMA (District Metered Areas). Today, through the control and measurement points (flow meters, water meters and other control devices and gate valves), the company analyses, online, about 150 DMA.

Such many areas subject to detailed analysis resulted in the extension of the balancing of water distribution processes and the interpretation of measurement results, indicating operational anomalies (water losses, network failures, etc.). The use of the system significantly improved these works.

The main factor that greatly increases the speed of analysing the situation in the water supply system is the integration of the analysed data. So far, in the Company, the data management process included three independently functioning systems: SCADA, billing and GIS. In order to optimize the operation of the operational data analysis system, RPWiK Tychy S.A. together with Kart GIS, it has developed an integrated data analysis system that enables:

- simultaneous processing of data from the following systems: SCADA, billing and GIS,
- automatic generation of DMA in the GIS system,
- creating dispatch reports and zone reports, allowing for the preparation of a comprehensive water balance for individual DMA.

The purpose of implementing the system was to introduce a new technology for controlling the distribution process, enabling the maintenance of the highest quality of water supplied to consumers, and thus minimizing the risk of its secondary contamination associated with this effect. The above process naturally contributed to the optimization of the operating costs of the water supply network and the increase in the effectiveness of the Company's operation.

***Keywords:*** *optimisation; water losses; water supply*

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## INTERNATIONAL PROJECTS

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## CIRCU-CITY

Project “**International summer school for students – Comprehensive solutions in cities – water, waste, energy**” (CIRCU-CITY), no.19185 (2020-2021) received funding from the European Institute of Innovation and Technology (EIT) – a body of the European Union, under the Horizon 2020 program. The project assumes the development of a training programme on the adaptation of selected elements of water, waste (including sewage) and energy management in cities to the assumptions of the sustainable development and the circular economy. As a part of the project a summer schools (in English) for students are organized in 2020 and 2021. The main topics of the summer school are identification and development of concept of innovative solutions in the circular use of water resources and modern energy solutions in urban areas.

The project is a continuation of the training program implemented by Ghent University in cooperation with the University of Queensland and MEERI PAS as a part of the “Water and Energy Systems Integration Summer School 2019” project.

### *Partners*



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[www.circucity.uqent.be](http://www.circucity.uqent.be)



## TransDOCSUM

Project “**Transfer of EIT Raw Materials PhD Summer School - Entrepreneurship in the CE**” (**TranDOCSUM**) no. 19091 (01.2020-12.2020) received funding from the European Institute of Innovation and Technology (EIT) – a body of the European Union, under the Horizon 2020 program. The project envisages the development of a training program to support entrepreneurship in the raw materials sector. As part of the project, a winter school (in English) for PhD students was organized in December 2020. The main topic was the transformation towards the circular economy (CE) with the focus on the possibility of recovering biogenic raw materials (phosphorus, nitrogen) from waste generated in sewage treatment plants, such as sewage, sewage sludge and ash from the incineration of sewage sludge. The project is a continuation of training programs implemented in cooperation with Katholieke Universiteit Leuven (KU Leuven) and Université de Liège. According to the assumed knowledge transfer, the organizers of the winter school are participants of the ‘train the trainers event’ (MEERI PAS, AGH, RISE IVF AB) who have been trained and prepared to organize a winter school in Regional Innovation Scheme (RIS) countries.

### Winter School description

The Winter School offers the PhD Students and Young Researchers an unique opportunity to acquaint to various elements of the CE implementation in the raw materials sector.

The main theme of the Winter School is the transformation towards the CE with the focus on the possibility of recovering the raw materials from waste generated in municipal waste processing plants, as well as building industrial symbiosis in the region and creating a positive image of the company among various stakeholder groups.

All participants gained a key skills in the area of innovative and entrepreneurial activities in the raw materials sector.

### Partners



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## InPhos

Project “**Sustainable management of phosphorus in the Baltic region**” (InPhos), no. 17022 (2018-2020) received funding from the European Institute of Innovation and Technology (EIT) – a body of the European Union, under the Horizon 2020 program. The main objective of the InPhos project is to develop a strategy for sustainable phosphorus management in the Baltic Sea Region by a working group of experts from the Baltic countries – Poland, Germany, Sweden, Finland, Latvia, Lithuania, Estonia and Italy. Strategic goals of the project:

- identification of best practices regarding the sustainable use of phosphorus in developed countries,
- identification of phosphorus recovery potential in the Baltic Sea region,
- transfer of knowledge and development of solutions for the sustainable use of phosphorus in the Baltic Sea Region,
- promotion of closing the phosphorus cycle in the Baltic Sea Region, in accordance with the assumptions of the circular economy (GOZ),
- raising environmental awareness of the inhabitants of the Baltic Sea Region.

### Partners



University of Bologna



Outotec



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# MonGOS

## MonGOS

Project “**Monitoring of water and sewage management in the context of the implementation of the circular economy assumptions**” (MonGOS) is financed by the Polish National Agency for Academic Exchange (NAWA) under the International Academic Partnerships Programme (2020-2022). The main goal of the project is to undertake international cooperation by leading scientific institutions in Europe in the field of water and sewage management. Strategic goals of the project:

- identification and assessment of the potential for transformation towards the circular economy in the water and sewage sector,
- exchange of good practices and transfer of knowledge between leading scientific institutions in Europe in the field of water and sewage management,
- development of circular economy monitoring framework in the water and sewage sector,
- development and implementation of a plan for the dissemination of international research results.

### *Partners*



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Economy Research  
Institute  
Polish Academy of Sciences



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## LEX4BIO

Project “**Optimising bio-based fertilisers in agriculture – Providing a knowledge basis for new policies**” (LEX4BIO) no. 818309 (2019-2023) has received funding from the European Union’s Horizon 2020 research and innovation program. This project aims to decrease the European dependency on finite and imported, apatite-based phosphorus and energy-intensive mineral nitrogen fertilisers. This will be achieved through the implementation of several objectives including:

- mapping at local, regional and European scale the nutrient availability to produce BBFs, assessing their potential and identifying legal barriers and constraints,
- identifying novel BBFs for crop production and determining their effect on soil quality and crop growth,
- determining the risks related to food safety, human health and environmental losses after application of BBFs and producing guiding principles for the safe use of BBFs,
- assessing the integrated ecological impacts over the entire lifecycle of the production and use of BBFs,
- determining the logistic costs, public perceptions and political actions required for optimal use of BBFs.

### Partners



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## PhosForce

Project “**Market ready technologies for P-recovery from municipal wastewater**” (**PhosForce**) (2018-2020) received funding from the European Institute of Innovation and Technology (EIT) – a body of the European Union, under the Horizon 2020 program.

The main goal of the PhosForce project is to develop an innovative technology for the recovery of phosphorus from sewage. The developed technology can be used for the recovery of phosphorus in the form of struvite crystals from wastewater produced in municipal waste disposal facilities.

### *Partners*



Mineral and Energy  
Economy Research  
Institute  
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## Leopold Oxelia™

### Biologically active filtration system supported by oxidation - Oxelia™

Xylem Oxelia is an advanced treatment solution. Harnessing the power of oxidation to enhance the treatment of a biologically activated carbon filter (BAC), Oxelia breaks down and removes the most difficult contaminants, including taste and odor-causing geosmin, 2-MIB and contaminants of emerging concern (CECs). Backed by Wedeco's expertise in ozone and UV treatment, YSI/WTW precision instrumentation and Leopold's unparalleled filtration capability, the Oxelia system can be configured precisely for your water matrix, energy and regulatory requirements for the most cost-effective solution.

Leopold Oxelia™ is used in the treatment of both treated wastewater and retention rainwater. In each of these two cases we set different tasks to be performed during the treatment process depending on the input parameters of the device and the purposes for which the water is to be used. In different configurations, based on our equipment, the process is individually selected for each application.

Both ozone generators and UV lamps used, combined with biologically active carbon, are effective microbiological barriers.

What can the Oxelia system treat?

- Taste and odor caused by geosmine and 2-MIB
- Residual pharmaceuticals
- Endocrine disrupting compounds (EDC) in medications and personal care products (PCP)
- Eliminates oxidation and disinfection byproducts
- Pesticides
- Micropollutants from industrial discharges such as NDMA, MTBE and 1,4-dioxane.

Xylem is an international team with a common goal: to create technologically advanced solutions to meet global water and wastewater challenges. Developing new technologies that will improve the way water is used, saved and reused in the future is crucial to our work. We offer products and services in the field of transportation, treatment, analysis, monitoring and return of treated water to the environment for municipal, industrial, residential, commercial and agricultural applications.

LEOPOLD  
a xylem brand

**OXELIA™**  
BIOLOGICZNIE  
AKTYWNY  
SYSTEM  
FILTRACJI WSPIERANY  
OZONEM.

Na całym świecie na ekosystemy wodne oddziałują niebezpieczne zanieczyszczenia, które nie są odpowiednio oczyszczane przez konwencjonalne systemy. Oxelia marki Leopold całkowicie niszczy te zanieczyszczenia i patogeny. Jest to w pełni zintegrowane, wielobarierowe rozwiązanie, które łączy w sobie synergie oczyszczania z utlenianiem ozonowym i biologicznym.

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Let's Solve Water

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Mineral and Energy  
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