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Abstracts

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SYNTHESIS AND PROPERTIES OF Ni_3B -BASED METAL-CERAMIC CONDUCTIVE TRACKS VIA MULTILAYER SCREEN PRINTING METHOD

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Abstract

Boride-based metal-ceramic pastes enables the fabrication of reliable resistive structures and conductive tracks that maintain stable performance characteristics under high temperatures and corrosive environments. Conductive tracks based on Ni_3B metal-ceramic pastes were synthesized using the multilayer screen-printing method. With an increase in thickness, the resistance of the conductive tracks decreases from $43.5\ \Omega$ to $11.7\ \Omega$. Simultaneously, samples produced using a three-stage deposition process exhibit resistances of $11.7\ \Omega$ and $15.4\ \Omega$, respectively. The topography of the insulating coating and the synthesized conductive tracks was studied using the infrared interferometry method. Inhomogeneities in the coating of the conductive tracks were detected in all four investigated samples. Their surface roughness (R_z) varies in the range from 8.65 to $16.94\ \mu\text{m}$. The obtained roughness values enable the synthesis of multilayer conductive tracks with a high level of adhesion. The structure of the tracks consists of light areas of the conductive phase and dark areas of glass-ceramic. It was established that strong bonding of these coatings is achieved due to the fusion effect of the glass-ceramic phase. Considering the small spread of microhardness ($205\ldots 260\ \text{HV}$), the conductive tracks synthesized by three-stage deposition have a more homogeneous structure than tracks obtained by the standard method. Furthermore, these tracks allow for the achievement of maximum power with minimal resource costs for multi-stage heat treatment.

Keywords: Ni_3B conductive tracks, metal-ceramic pastes, multilayer screen printing, surface roughness, microhardness.

MICROSTRUCTURAL AND CHEMICAL CHARACTERISTICS OF HEAT-RESISTANT NICKEL ALLOY POWDERS FOR ADDITIVE MANUFACTURING

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Abstract

The morphological, microstructural, and chemical characteristics of powders of heat-resistant nickel alloys CrNi50WMoTiAlNb and CrNi60WTi obtained by the centrifugal plasma atomization method were investigated. It was established that the powders of both alloys are characterized by a predominantly spherical particle shape, indicating the stability of the atomization process and providing high powder flowability required for additive manufacturing. It was shown that a developed dendritic microstructure forms on the particle surfaces, resulting from high cooling rates and microsegregation of alloying elements during solidification. Elemental analysis confirmed that the chemical composition of the powders corresponds to the nominal composition of the initial electrodes, with a stable content of the main alloying elements and no evidence of their loss during the atomization process. Local defects in the form of oxide and nitride inclusions were detected, associated with the presence of residual oxygen and nitrogen in the working chamber. It was established that Al₂O₃ and TiN inclusions lead to a local disruption of chemical homogeneity. The obtained results demonstrate that the studied powders generally meet the requirements for feedstock for powder-based 3D printing. At the same time, the necessity of further optimization of the gas atmosphere during atomization to reduce defect formation and improve powder quality was substantiated.

Keywords: heat-resistant nickel alloys, alloy powders, additive manufacturing, centrifugal plasma atomization, microstructural analysis.

INVESTIGATION OF THE TRIBOLOGICAL BEHAVIOR OF PLA DEPENDING ON THE INFILL ARCHITECTURE

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Abstract

The aim of the conducted work was to evaluate the impact of the internal infill geometry of polylactic acid (PLA) components, manufactured via 3D printing using Fused Deposition Modeling (FDM), on their tribological behavior under abrasive wear conditions. Five infill types (Cubic, Grid, Gyroid, Hilbert Curve, and Archimedean Chords) were analyzed under identical printing parameters. The selection of these patterns was determined by the difference in their topological complexity and their ability to distribute contact stresses during mechanical loading. Wear resistance assessment was performed in accordance with the ASTM G65-16 standard by determining the mass and volume loss of the specimens during friction against loose abrasive particles. The results showed that the infill type significantly affects the wear rate and the microgeometry of the friction surfaces. A "negative wear" effect (mass gain) was established for the Grid and Gyroid structures, which is attributed to the formation of a "polymer-abrasive" composite layer within the open cells of the structure at high roughness values. Such surface morphology facilitates the mechanical anchoring of hard particles of wear debris within the interlayer voids. The highest wear resistance was demonstrated by the Archimedean Chords infill type due to the high density of fusion lines, which acts as a barrier to the abrasive. The obtained data allow for the optimization of 3D printing parameters for tribopairs, ensuring a balance between the weight of the component and its durability. Implementation of the derived recommendations will enable the purposeful design of parts and products with high wear resistance adapted to specific operating conditions in abrasive environments.

Keywords: PLA, 3D printing, infill geometry, abrasive wear, tribology.

ANALYSIS OF TEXTUAL PARAMETERS OF NATURAL LANGUAGE COMPONENTS FOR SYSTEMS FORMING PROBLEM-SOLVING PROCESSES

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Abstract

The aim of the work is to develop parameters characterizing text descriptions, on the basis of which methods for forming the process of approximate solution of a selected problem can be implemented. In most cases, solving problems consists in initially conducting an analysis of various aspects related to the solution of the formulated problem. Thanks to this, it is possible to create a textual description of the process of approximate solution of the formulated problem. The use of textual descriptions for forming ways of approximate problem solving and the use of textual descriptions of problem conditions, problem solving goals and additional information, which is usually presented in the form of textual descriptions, will facilitate the processes of building mathematical models of appropriate solutions. This is particularly characteristic for situations where tasks concern a domain for which, in most cases, there are no strict and precise data and possible mathematical models for their solutions. The work proposes a number of parameters of a semantic, interpretative and informative nature and their characteristics, thanks to which it is possible to carry out analysis of textual descriptions and individual textual components, using different types of logics, for example temporal logic. The work briefly presents a possible direction of development of the described approach, the development of which will allow to automate the process of generating a textual description, which, with a certain approximation, will describe a possible method for solving the formulated problem. Based on the use of textual descriptions, it is possible to expand the capabilities of an appropriate system to generate mathematical models of appropriate processes, useful for implementing control of appropriate processes or objects.

Keywords: semantics, interpretation, text description, text component, parameter, temporal logic.

NEW TECHNOLOGIES IN GRAPHIC DESIGN AS A TOOL FOR COMMUNICATING ENVIRONMENTAL PROBLEMS

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Abstract

Contemporary environmental challenges, such as climate change or energy transformation, generate large amounts of complex data, the interpretation of which constitutes a significant communication barrier. These data, despite their high scientific value, are often not effectively assimilated by non-specialist recipients, which limits their impact on social awareness and decision-making processes. The aim of the work is to analyze the role of new technologies in graphic design as a tool supporting the communication of environmental problems and shaping pro-ecological attitudes. The research methodology includes analysis of literature in the field of data visualization, visual communication and image perception, qualitative analysis of selected graphic forms using environmental data, and modeling the process of visual communication in the relationship: data – visual form – perception – emotions – attitudes. The analysis is supplemented by a case study of the dynamic visualization "Climate Spiral", based on NASA GISS data.

The results of the analysis indicate that the use of generative, dynamic and interactive forms increases the readability of data and promotes emotional engagement of recipients. A properly designed visual form enables intuitive reading of long-term environmental trends without the need for analyzing complex statistical charts, while strengthening the educational message.

The conclusions confirm that graphic design, supported by new technologies, constitutes an important tool for ecological communication and supports educational and social processes related to sustainable development, integrating the perspective of scientific data with the recipient's perception and experience.

Keywords: graphic design, data visualization, environmental communication, new technologies, visual perception, climate change, sustainable development.

ADVANTAGES AND DISADVANTAGES OF SELECTED METHODS OF DRYING WASTE FROM THE AGRI-FOOD INDUSTRY

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Abstract

There are many methods of drying waste and by-products from the agri-food industry (AFI) in order to produce animal feed, snacks, fertilizers and energy raw materials. In the AFI, many by-products and organic and inorganic waste are generated. The largest mass is apple pomace, which can also be processed into biofuel. The aim of the analyzes was to present the advantages and disadvantages of selected methods of drying waste from the AFI. The work included natural, convection, and microwave drying methods and other techniques used in industrial practice. Comparisons were made in terms of the efficiency of the drying process, energy demand, process duration, operating costs, impact on material quality, and potential environmental impact.

As a result of the conducted analyzes, it was found that the selected waste drying methods from the AFI differ in energy efficiency, operating costs, and impact on the quality of the end product. Drying allows for a significant reduction in the mass and volume of waste, which facilitates its storage, transport, and further use; properly dried waste, such as apple pomace, can be managed as biofuel, a feed component, or a raw material for fertilizer production, which promotes the circular economy. Each of the analyzed methods has both advantages and limitations. The choice of optimal technology should depend on the type of waste, production scale, and available energy resources; implementing effective drying methods contributes to reducing the negative impact of waste on the environment and increasing its utility value.

Keywords: natural drying, microwave, convection, drying methods, waste, agri-food industry.

WATER QUALITY ANALYSIS IN THE ŁUBINKA STREAM

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Abstract

The aim of this work was to evaluate the water quality of the submontane Łubinka stream according to physicochemical parameters and to determine the water quality class in relation to the applicable legal standards. The research was carried out based on monitoring parameters at two representative sampling points, selected to reflect the gradient of changes occurring in the catchment area under the influence of human activity. The first point was located before the stream entered the urbanized area, while the second point was situated at its mouth to the Dunajec River. Samples were collected in the spring and autumn cycles, which allowed for a broader assessment of water composition variability. The scope of research included the analysis of key indicators, such as: temperature, pH, electrical conductivity (EC), and concentrations of nutrients and dissolved oxygen. The research results indicate anthropogenic pressure, manifested by the deterioration of parameters at the discharge point relative to the reference site. Increased concentrations of nitrogen and phosphorus compounds were recorded, resulting mainly from surface runoff from agricultural areas and probably leaky sewage management in built-up areas. It was found that the waters of Łubinka in the studied section for most of the tested parameters are at a good or moderate level. Improving water quality requires taking corrective actions within the catchment area, with particular emphasis on the modernization of sanitary and living infrastructure.

Keywords: surface water, eutrophication, nutrients, water quality.

IMPACT OF AMBIENT TEMPERATURE CHANGES ON ENVIRONMENTAL EFFECTS OF HEAT STORAGE IN A STONE ACCUMULATOR

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Abstract

In the face of growing challenges related to thermal energy storage and the need to implement sustainable technologies, increasing attention is paid to new ecological solutions. One such solution is a stone accumulator used for short-term heat storage and its use in the air exchange process in a building. Previous studies focused mainly on assessing the energy efficiency of such systems, while there is a lack of analysis of their environmental impact. The main goal of the work was the life cycle assessment (LCA) of the heat storage system in a stone accumulator supported by a photovoltaic installation. Furthermore, an analysis of the impact of ambient temperature fluctuations on the environmental effects of the heat storage system in a stone accumulator supported by a photovoltaic installation was carried out. The analysis covered the entire life cycle of the system from component manufacturing, through soil preparation, accumulator construction, material transport, to its operation in cooperation with a foil tunnel for one growing season, as well as the photovoltaic installation. The functional unit was 1 m² of stone accumulator surface. The LCA assessment was carried out in SimaPro 8.1 using the Ecoinvent database and the ReCiPe method. The greatest negative environmental impact was found at the stage of raw material extraction and component production (32.38 Pt). Heat storage in one season (from April to October) allows for a reduction of negative impact by about 7%, while an increase in average air temperature by 3°C results in an additional reduction of about 0.7%.

Keywords: heat accumulator with a rock bed, life cycle assessment, heat storage, photovoltaic system.

UTILIZATION OF THE HYDRAULIC HAMMER PHENOMENON IN PUMPING SYSTEMS

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Abstract

The phenomenon of hydraulic hammer is usually perceived as unfavorable in classic hydraulic systems because it leads to sudden pressure changes, dynamic loads and accelerated wear of installation components. In the authors' previous works, this issue was analyzed mainly in the context of its limitation and minimization of effects. This study constitutes a continuation of earlier research, proposing an alternative approach consisting in the intentional use of hydraulic hammer energy in pumping systems.

The subject of the research is a hydraulic water ram – a device that enables lifting water to a higher level without using an external energy source, solely through the conversion of the kinetic energy of the water stream into pressure energy. The paper presents the operating principle of the water ram and the hydraulic conditions necessary for its stable and effective operation, with particular emphasis on the role of height difference, flow losses and shock valve characteristics.

The analysis was based on relationships resulting from the Bernoulli equation, taking into account linear and local losses and on operational observations of a prototype device working in real field conditions. Many years of operation have confirmed the reliability of the solution and its usefulness in systems requiring autonomous water transport. The results obtained indicate that the hydraulic hammer phenomenon, properly controlled, can constitute an effective and ecological energy source in simple pumping systems, consistent with the idea of sustainable water resource management.

Keywords: hydraulic hammer, ram, kinetic energy, water, pressure, shock valve, flow.

ROBOTIZATION OF THE CAR BODY COMPONENTS STAMPING PROCESS

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Abstract

The report contains an overview of contemporary technologies for stamping external car body elements on robotized lines. The aim of the study is to optimize the operating parameters of robots feeding and receiving stamped elements using a controller working in the PROFIBUS RS485 industrial network standard, with focus on the coordination and effective work of each element belonging to the system. The controller has the ability to give a permission signal to only one of a pair of robots for the gripper to enter the working zone. Two collision zones were determined, of which the first secures space on the positioning table, while the second prevents the gripper from entering the common space with the gripper located in the press working space. Achieving the designated line tempo required optimizing the robot arm movement speed, the 'Pick up time' for the time of generating the threshold gripper air vacuum 'Intake time', the 'Drop off time' of the gripper return movement, and the 'Enable D2' parameter of the gripper entry lead before the press before the slider reaches the upper position. The possibility of obtaining the required line tempo for 6 650/400T presses stamping an example roof profile of the FIAT 500 Convertibile was demonstrated.

Keywords: car body press line, PROFIBUS industrial network, destacker, gripper, line tempo, stamping process optimization.

RESEARCH AND ANALYSIS OF END PRODUCTS OF ORGANIC MUNICIPAL WASTE PROCESSING – USE IN TERMS OF THE CIRCULAR ECONOMY

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Abstract

Municipal organic waste constitutes one type of waste generated mainly in households but also by other producers. Key in the management of this waste is the use of appropriate processing methods in order to limit the negative impact of this waste on the environment. In the composting process, the decomposition of persistent organic pollutants occurs, along with their binding to the organic fraction. In this work, research and analyzes were performed in quantitative and qualitative terms of organic waste contained in mixed municipal waste and selectively collected waste in Poland from 2020 to 2024. The aim of the work was to compare the final parameters of two types of organic waste after the processing process and to indicate the way forward to evaluate the possibilities of their diversification of management in the context of the circular economy and reduction of greenhouse gas emissions. The research results showed the use of the same processing processes for the two analyzed organic waste streams. However, the waste and end products resulting from biological processing showed a high diversity of their physicochemical parameters, which results in the use of different management methods. The resulting compost as a potential fertilizer must meet the quality requirements for an organic soil improver. The resulting waste that does not constitute fertilizer can be used for land reclamation and intended for landfilling if it collectively meets three criteria: AT4 value < 10 mgO₂/g d.m., ignition loss value less than 35%, and organic carbon content below 20% of dry mass. The products of biological organic waste processing processes constitute fertilizers and stabilized waste 'stabilizate' intended for further processing.

Keywords: organic waste, circular economy, recycling, environmental protection, biological waste treatment.

ANALYSIS OF PROCESSED ORGANIC MUNICIPAL WASTE PARAMETERS – TECHNOLOGIES FOR THE CIRCULAR ECONOMY

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Abstract

Municipal organic waste requires the application of optimal processing methods in order to limit the negative impact of this waste on the environment. The aim of the work was to compare the final parameters of 'stabilizate' generated in 6 selected waste treatment plants representing different processing technologies, in the context of their further management in terms of the circular economy. Quantitative and qualitative analyzes were performed in the work, which showed that in cases where 'stabilizate' waste meets three criteria collectively: AT4 value < 10 mgO₂/g d.m., ignition loss value less than 35%, and organic carbon content below 20% of dry mass, such waste parameters allow for further management in accordance with the hierarchy of waste handling for the reclamation of landfills and degraded areas (compost not meeting requirements) and intended for landfilling. The analysis showed that the final parameters of biological waste processing depend on the type of plant in which they were processed. A key aspect is the duration of a given process and the type of technological processes used.

Keywords: municipal organic waste, circular economy, stabilizate, recycling, environmental protection, biological waste treatment.

SEASONAL VARIABILITY OF PM₁₀ CONCENTRATIONS IN A SELECTED POLISH HEALTH RESORT

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Abstract

Air pollution with PM₁₀ particulate matter constitutes a serious environmental and health problem not only in urban areas but also in health resorts, especially during the heating season. Long-term exposure to suspended particulate matter may increase the risk of diseases of the upper respiratory tract and the cardiovascular system. The aim of this study was to analyze the seasonal variability of PM₁₀ concentrations between 2020 and 2023 in Rabka-Zdrój, a mountain health resort located in southern Poland, based on data obtained from the Chief Inspectorate of Environmental Protection (GIOŚ). Despite the absence of exceedances of the alarm level, local exceedances of permissible daily standards were recorded, which may negatively affect the ecological and health safety of residents and spa visitors. The highest PM₁₀ concentrations occurred during the winter season.

Keywords: atmospheric pollution, air quality, health resorts, environmental pollution, PM 10.

SHAPE OF PARTICLES IN WASTE WITH A FRACTION BELOW 10 MM: ENVIRONMENTAL AND HEALTH SIGNIFICANCE

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Abstract

The aim of the work is to assess the environmental and health significance of the size and shape of particles occurring in waste with a fraction below 10 mm, coming from street sweeping. The fine fraction constitutes the most problematic part of this waste, due to high specific surface area and ability to sorb pollutants such as heavy metals, polycyclic aromatic hydrocarbons, microplastics and tire rubber wear. Irregular particle morphology additionally increases their chemical reactivity and mobility in the environment, promoting the migration of pollutants to soil, surface waters and storm sewers. An important problem is also secondary dusting, leading to the emission of fine dust fractions (PM₁₀, PM_{2.5}, PM₁), which pose an inhalation threat and can accumulate in the human respiratory system. Particles with sharp, irregular shapes can also cause skin micro-damage, increasing the penetration of toxic substances. The complex chemical nature of this fraction – often carrying mixtures of metals and organic compounds – intensifies the toxic effect through additive and synergistic mechanisms. Results of the analysis indicate that the fraction <10 mm from street sweeping requires a detailed risk assessment, constituting a key element in the processes of management and possible material utilization in accordance with the principles of the circular economy.

Keywords: fine waste fraction, particle morphology, environmental risk, health impact, pollutant migration.

RISK ASSESSMENT FOR NEW MATERIALS SIMILAR TO LIGHTWEIGHT AGGREGATES, FORMED FROM FINE-FRACTION WASTE

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Abstract

The aim of the study is to assess the risks associated with the use of new materials with properties similar to those of lightweight aggregates, produced from fine-fraction waste subjected to recovery processes. The study analyzed the physical, mechanical, and environmental parameters of the developed materials, with particular emphasis on their stability, durability, and potential emission of pollutants under operating conditions. The risk assessment was carried out based on guidelines for building materials and criteria used in the circular economy. The results indicate that appropriately selected processes for the preparation and forming of fine fractions make it possible to obtain materials with parameters similar to commercial lightweight aggregates, while reducing the environmental impact. However, areas requiring further verification have been identified, including long-term chemical stability and behavior under variable loads. The risk assessment provides a basis for further work on the implementation of this type of material in engineering practice, supporting the development of technologies in line with the principles of the circular economy.

Keywords: fine-fraction waste, lightweight aggregates, risk assessment, environmental impact, circular economy.

FROM WASTE TO SOIL: THE FATE OF MICROPARTICLES IN COMPOSTS AND THEIR SIGNIFICANCE

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Abstract

Composting organic waste is widely recognized as a pro-ecological method of its management, but this process can lead to the introduction of microparticles, including microplastics, into the soil. Microparticles present in composts originate from, among others, packaging, textiles and other pollutants entering the bio-waste stream. After application of compost to the soil, they may undergo accumulation, affecting the physical, chemical and biological properties of the soil environment. Understanding the fate of microparticles in composts and their impact on soil ecosystems is of key importance for assessing the safety and sustainable use of composts in agriculture and environmental protection. The aim of the work was to examine microplastic pollution of selected composts. The performed FT-IR analysis of the collected stabilize samples showed the presence of polymer microparticles.

DLS analysis provided information about the size of nano and microplastics present in the stabilize with an average size of 465 nm, and individual nanoparticles of about 32 nm were also measured. Instead of landfilling the stabilize in landfills, new forms of its use should be sought due to the presence of a large amount of microplastics in it.

Keywords: microplastics, nanoplastics, waste, composting, soil, FT-IR, environmental pollution.

ENVIRONMENTAL SAFETY OF COMPOSTS IN THE CONTEXT OF THE PRESENCE OF NANO- AND MICROPARTICLES

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Abstract

Polymer nano and microparticles are now commonly found in all environmental components. More and more waste is being generated worldwide. One form of waste processing is the composting process. This work presents four types of composts that were examined for the particle size occurring in them. Thus, sequentially studied were: composted grass, home compost, soil improver created after composting green waste, and stabilizate – waste resulting from mechanical-biological treatment of municipal waste collected from a mechanical-biological municipal waste treatment plant. 30 samples were taken from each group of composts. DLS (dynamic light scattering) analysis was performed to measure particle size. The following average particle sizes were measured: for composted grass – 222 nm, for home compost – 1302 nm, for soil improver – 746 nm, and for stabilizate – 649 nm. It was found that the smallest polymer particles are in composted grass, and the largest in the soil improver.

Keywords: polymer particles, compost products, particle size distribution, soil improver, FT-IR analysis.

ANALYSIS OF MINIMUM FLUIDIZATION VELOCITIES DURING THE WASHING OF SPECIFIC FILTRATION MATERIALS

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Abstract

Washing filter beds is an important unit process of rapid filtration. The beginning of washing is determined by the minimum fluidization velocity (V_{mf}), at which the bed begins to rise and passes into a fluid state. Thus, the V_{mf} velocity is the minimum flow value for which the washing pump is selected.

The aim of the research was to laboratory-determine the physical parameters of selected beds such as sand, hydroanthracite, and high and low density expanded clay. The obtained parameters formed the basis for calculating the V_{mf} velocity using the equations most commonly found in the literature. The results of these calculations were compared with the experimental determination of the minimum fluidization velocity in laboratory scale. Based on the conducted analyzes, appropriate mathematical equations were matched to specific types of beds, whose results most closely corresponded to the results obtained during laboratory tests. The minimum fluidization velocity of sand filter beds and beds made of high-density expanded clay is best determined using Gidaspow's formula, while the minimum fluidization velocity for a hydroanthracite filter bed and a low-density expanded clay bed will be most accurately determined by the formula proposed by Majcherek.

Keywords: bed washing, expanded clay, sand, fluidization, rapid filtration.

COMPLAINTS AS A SOURCE OF REDUCTION OF MATERIAL LOSSES AND ENERGY CONSUMPTION IN PRODUCTION

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Abstract

Customer complaints are an important source of feedback between the market and the company's production system. Their proper analysis can support the reduction of material losses and the reduction of the energy intensity of production processes. The aim of the article is to assess the possibility of using complaint data to improve production processes on the example of a company producing cylinders for hydraulic actuators. The research used documentary analysis, a case study and selected quality management tools such as FMEA, Pareto-Lorenz diagram, Ishikawa diagram and the PDCA cycle. The results confirm that a systematic approach to complaint handling allows the identification of key causes of non-compliance generating material losses and excessive energy consumption. The implementation of corrective actions leads to improved efficiency of production processes and reduction of the company's operating costs. Conclusions: 1. Customer complaints are an important source of information enabling the identification of material losses and areas of excessive energy intensity in production, especially in the case of repetitive non-conformities. 2. The use of quality management tools allows for effective identification and elimination of the causes of complaints, leading to a reduction in losses and improvement in process efficiency.

Keywords: complaints, material losses, energy intensity, quality, FMEA, process improvement.

THE FOLLOW-UP PHOTOBIOREACTOR ILLUMINATION SYSTEM FOR THE CULTIVATION OF PHOTOSYNTHETIC MICROORGANISMS

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Abstract

The objective of this work was to develop a conceptual design of a cylindrical photobioreactor (PBR) for algae cultivation, equipped with a closed-loop illumination system. The reactor integrates three independent, interconnected LED lighting modules enabling full control of irradiance and spectral composition. The lighting system is based on RGBW and RGB LEDs and is coupled with on-line measurements of photosynthetically active radiation (PAR) and optical density (OD) of the culture medium. These signals are used as feedback variables for real-time compensation of light attenuation and non-uniform photon flux distribution within the reactor volume.

A pilot study was performed using a simplified PBR prototype dedicated to light distribution and optimization in microalgae cultures for energy-oriented biomass production. Experiments were conducted on *Chlorella vulgaris* BA0002a. The control concept allows automatic or manual adjustment of illumination parameters during cultivation, based on continuous sensor feedback, thereby maintaining target PAR levels despite increasing biomass concentration and decreasing medium transparency. The proposed solution addresses a key limitation of conventional PBRs, where light gradients are not compensated in real time. Pilot results confirmed significant spatial differences in available light energy inside the reactor, with distribution patterns changing dynamically as biomass increased.

Keywords: cylindrical LED light coat, photosynthetic microorganisms, photobioreactor, algae.

GREEN LEAN CIRCULAR – SYNERGY OF CONCEPTS IN SUSTAINABLE PRODUCTION ENGINEERING

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Abstract

Contemporary production enterprises face the challenge of reconciling operational efficiency with sustainable development. Lean Manufacturing, Green Manufacturing and Circular Economy are often implemented separately. The aim of the research was a systematic synthesis of the literature regarding the integration of these three paradigms, with particular emphasis on the role of Industry 4.0 technology. A methodical review of the literature was conducted based on the Scopus and Web of Science databases using keywords combining the concepts of Lean, Green, Circular Economy and Industry 4.0. Inclusion criteria included peer-reviewed scientific articles referring to the manufacturing sector, published in English or Polish.

Three main integration trends were identified: (1) Circular Lean – combining the elimination of waste with the closing of material and energy loops; (2) Digital Green Lean – using I4.0 technologies (IoT, AI, Big Data) to optimize lean-green practices; (3) Smart Lean Green Production – a holistic paradigm for improving operational and environmental results. The results of empirical research indicate that coordinated integration of circular economy (CE) practices, Industry 4.0 (I4.0) technologies and the Lean approach is associated with improving sustainable development results in terms of the triple bottom line (economic, environmental and social). The integration of Lean-Green-Circular paradigms supported by I4.0 technologies constitutes a promising approach to the transformation of sustainable production. The Digital Green Lean concept requires changes in organizational culture and leadership style.

Keywords: green, lean, sustainable production engineering, circular economy, I4.0.

POSSIBILITIES OF USING METHANE FERMENTATION TECHNOLOGY FOR SEWAGE SLUDGE FROM DAIRY PRODUCTION WASTEWATER TREATMENT PLANTS WITH THE ADDITION OF AN EMULSIFIER

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Abstract

The management of liquid waste from the dairy industry constitutes an important technological, economic, and environmental problem. Recently, more and more attention has been paid to the possibility of obtaining biogas from sewage sludge generated in on-site wastewater treatment plants. The aim of the work was to examine the impact of the addition of an emulsifier in the form of a carboxymethylcellulose solution to the composition of fermentation substrates based on sewage sludge from the dairy industry on the quantity and quality of emitted biogas. The adopted research goal was achieved based on a laboratory experiment, which consisted in conducting methane fermentation of sludge with the addition of an emulsifier. A fat emulsifier was added to each substrate made on the basis of these samples in concentrations: 1%, 2.5%, 5%, and 10% of the fresh mass of the load. A 55% carboxymethylcellulose solution was used as an emulsifier because this emulsifier is most commonly used in food production. The experimental study aimed to determine how the addition of an emulsifier (55% carboxymethylcellulose solution) affects the hydration of poorly water-soluble fractions during methane fermentation using sewage sludge as an example. The samples were subjected to static methane fermentation according to the DIN 38414 standard methodology. The experiment lasted 30 days. For dairy sewage sludge, the highest total yield was recorded for the 2.5% CMC variant – 209.46 Ndm³/kg d.m., the average total yield was equal to 140.1 Ndm³/kg d.m.; the variant was characterized by high process stability, with the 5% CMC variant showing slightly higher stability. The biogas quality was also high, and the CH₄ share remained at the level of 55-58%. Although the 2.5% variant was characterized by a high total yield, the differences between the variants were small, indicating a natural high susceptibility of the substrate to fermentation. In this fraction, the addition of an emulsifier performed a process-stabilizing function and improved biogas quality; its stimulating influence was less significant.

Keywords: dairy industry, sewage sludge, carboxymethylcellulose, methane fermentation.

THE ROLE OF SOCIAL LICENSE TO OPERATE (SLO) IN STIMULATING INNOVATIVE SOLUTIONS ON THE EXAMPLE OF MINING PROJECTS

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Abstract

Social License to Operate (SLO) constitutes an increasingly important factor conditioning the functioning of mining projects in conditions of growing social, environmental and regulatory pressure. While large mining enterprises report their activities in accordance with CSR and ESG principles, in the case of small business entities these practices are not common or sufficiently recognized. This is confirmed by the results of work carried out within the RMHubPlus and Pro-Slo projects, in which the SLO Atlas of Good Practices was developed. Analysis of the collected examples indicates that the activities of small companies related to building relationships with local stakeholders are most often fragmentary and informal. The aim of the article is to analyze the role of SLO as a mechanism stimulating the implementation of innovative technological, organizational and social solutions in the mining sector, in particular by increasing social acceptance for the conducted activity. The work adopted a qualitative approach, based on an analysis of the literature on the subject and case studies of selected small mining entities in Poland, in which relations with local stakeholders played a key role in the decision-making process. The results of the analysis indicate that striving to obtain and maintain SLO promotes the development of innovations aimed at minimizing environmental impacts and increasing transparency of activities and implementing circular economy models. A good practice is the ValorWaste (ERA-MIN) project, within which at the Awida mine, overburden and materials from surrounding mining plants were used to develop recipes for new construction materials.

Keywords: social responsibility, raw materials, innovations, sustainable development, mining.

IMPACT OF CLIMATIC STRESS TESTING ON THE ELECTRICAL PROPERTIES OF SIDE CONNECTORS IN GLASS-GLASS PHOTOVOLTAIC MODULES

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Abstract

This study evaluates the electrical performance and durability of side connectors integrated into glass-glass photovoltaic modules. Unlike standard PV modules, which use rear-mounted junction boxes requiring openings in the laminate, side connectors are partially laminated between two glass layers, eliminating complex hole-preparation processes and offering greater design flexibility for BIPV applications. Glass-glass PV samples with side connectors were fabricated and tested under environmental conditions following PN-EN-61215-2 standards. Insulation resistance was measured in dry and wet conditions, with initial values significantly exceeding minimum safety requirements—reaching the GΩ range (dry) and MΩ range (wet). After exposure to climatic stress tests (MQT-11, MQT-12, MQT-13), insulation resistance decreased by approximately one order of magnitude, and visual changes appeared near the lamination-connector interface. The results indicate strong potential for using side connectors as an alternative to conventional junction boxes, while also highlighting technological challenges that require further development.

Keywords: glass-glass photovoltaic modules, side connectors, climatic stress testing, electrical performance, insulation resistance.

IMPACT OF DECORATIVE CERAMIC SCREEN PRINTING ON THE OPTICAL AND PHOTOVOLTAIC PERFORMANCE OF GLASS COVERS FOR BIPV APPLICATIONS

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Abstract

This study investigates the optical and electrical performance of glass substrates coated with various decorative ceramic prints intended for Building Integrated Photovoltaics (BIPV). Achieving a balance between aesthetic architectural requirements and energy conversion efficiency remains a critical challenge for BIPV integration. In this work, nine ceramic-printed glass samples, characterized by different colors and opacities (including Dark Grey, Anthracite, Silver, and Gold), were analyzed using UV-VIS-NIR spectrophotometry and Energy Dispersive Spectroscopy (EDS).

Optical transmission analysis revealed that while the reference Optiwhite glass maintained peak transparency, the ceramic-coated samples exhibited varying transmittance levels, typically ranging from 60% to 80% in the visible spectrum. The integration of these glass covers with silicon solar cells demonstrated a direct correlation between decorative print density and photovoltaic performance degradation. Power output losses ranged from approximately 17% for the most transparent "Dark Grey" (sample 7265) to over 32% for "RGB Grey" (sample 7756) compared to the reference Optiwhite glass.

The chemical composition analysis confirmed that the coatings consist of organic carriers and glass frit containing compounds such as zinc oxide and silica, alongside inorganic pigments. Furthermore, the thermal processing required for curing these prints (650-720°C) aligns with glass tempering standards, ensuring structural suitability for building facades. The findings provide essential quantitative data for architects and solar engineers to optimize the trade-off between visual appearance and energy yield in colored BIPV modules.

Keywords: BIPV, ceramic screen printing, optical transmittance, photovoltaic efficiency, building integration, decorative solar glass.

POSSIBILITIES OF MANAGEMENT OF RECYCLED AGGREGATES FOR CONCRETE PRODUCTION

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Abstract

The development of construction makes the demand for concrete mixtures constantly increase. Construction production, as well as repairs and demolitions of buildings, generate significant amounts of waste such as concrete rubble. Theoretically, any demolition rubble can be processed to obtain a full-value secondary raw material. The problem may be its application due to the content of various unfavorable substances (e.g. chlorides occurring in road surfaces). As follows from standards and conducted research, recycled aggregate can be successfully used for the production of low-grade concretes as a replacement for part of the coarse aggregate, i.e., with grains larger than 4 mm. The main goal of the research work was to check the decrease in concrete strength when replacing part of the coarse aggregate with one coming from recycling and the possibility of making concrete on aggregate coming exclusively from demolition. A sieve analysis of the recycled aggregate composition was performed and compressive strength was tested at various percentages of added recycled material. It was found that the addition of coarse aggregate to concrete in an amount not exceeding 50% reduces the strength of the concrete by about 30%. The main conclusion resulting from the conducted research is the possibility of obtaining concrete of a low strength class when using recycled aggregate in the range allowed by European standards (EC). At the same time, this concrete is characterized by lower strength compared to concrete on natural aggregate. The research confirmed that recycled aggregate is not suitable for the production of higher strength class concretes, while mixtures containing 100% recycled aggregate, as non-standard concretes, can be used exclusively as sub-layers.

Keywords: recycling, concrete, aggregate, construction.

ANALYSIS OF PHYTOTOXICITY OF SOILS IN THE VICINITY OF A MECHANICAL-BIOLOGICAL MUNICIPAL WASTE TREATMENT PLANT

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Abstract

The environmental impact of such facilities as composting plants, biogas plants, sorting plants, and landfills has been widely described in the scientific literature. However, there is a lack of studies on the actual environmental impact of mechanical-biological treatment (MBT) plants for mixed municipal waste. Plants of this type constitute an important link in the waste management system; however, their activity is associated with the emission of various harmful substances into the environment. The analysis of these pollutants is key in assessing the risk to ecosystems and human health. The aim of the conducted research was to perform an analysis and assessment of the impact of the operation of the MBT plant on the phytotoxicity of soils on the plant premises and in its vicinity. To perform phytotoxicity tests, soil samples were collected from over 30 locations. The test plant was white mustard (*Sinapis alba* L.). Although the presence of plastic and microplastic in the soil was discovered on the plant premises, it was not found that the operation of the plant negatively affected soil phytotoxicity. However, a negative impact on the organic matter content in the soil was observed.

Keywords: municipal waste, MBT plant, phytotoxicity.

FOOD UPCYCLING AS A TOOL SUPPORTING SUSTAINABLE CIRCULAR ECONOMY MODELS

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Abstract

Food waste constitutes a global problem occurring at all stages of the food supply chain. Response to this challenge is the circular economy (CE), in which waste is treated as a resource and food upcycling enables converting by-products and waste streams into valuable products for human consumption. The aim of the work is to indicate the role of food upcycling in sustainable CE models. A review of scientific literature was conducted using Scopus and ScienceDirect databases. Peer-reviewed scientific articles on food upcycling and CE, searched on the basis of keywords, were included in the analysis. Upcycling constitutes an intermediate strategy between waste prevention and recycling or disposal, allowing to maintain the material and nutritional value of raw materials in the economic cycle. Most commonly used are: fruit and vegetable pomace, brewer's spent grain, plant pulps, by-products of the oil and coffee industries. Food upcycling constitutes an effective CE tool in the food sector, enabling the use of by-products without losing their nutritional potential, and the development of these technologies fits into the assumptions of sustainable food production systems.

Keywords: food upcycling, circular economy, by-products, production engineering, sustainable development.

SUSTAINABLE ROAD TRANSPORT IN THE CONTEXT OF ENERGY TRANSFORMATION AND ECOLOGICAL CHALLENGES: THE ROLE OF MODERN DRIVE SYSTEMS IN SHAPING THE MOBILITY OF THE FUTURE

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Abstract

Road transport remains one of the key sectors affecting the environment through greenhouse gas emissions, energy consumption and impact on air quality. Under the conditions of progressive energy transformation and tightening environmental regulations, this sector is undergoing intensive technological and organizational changes. Modern drive systems play an important role in this process, perceived as a tool for limiting the negative impact of transport on the environment. The aim of the paper is to analyze the importance of contemporary drive technologies in shaping sustainable road transport. Current development trends are presented, covering both the development of electric and hybrid drives, as well as activities aimed at improving the energy efficiency of internal combustion engines and the use of alternative fuels. The analysis is carried out in environmental, technological and economic terms, taking into account emissions throughout the vehicle's life cycle. The results indicate that the pace of transport transformation is determined, among others, by the availability of infrastructure, operating costs and regional conditions. Achieving sustainable development goals requires a systemic approach that assumes the coexistence of various drive technologies, rather than solely unilateral electrification of transport.

Keywords: sustainable transport, energy transformation, drive systems, electromobility, hybrid drives, alternative fuels.

REDUCTION OF SANITARY INDICATORS IN THE BIOLOGICAL WASTEWATER TREATMENT PROCESS

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Abstract

The aim of the research was to evaluate the effectiveness of eliminating sanitary indicators (thermotolerant coliform bacteria, *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Clostridium perfringens*, enterococci), in the biological wastewater treatment process using the activated sludge method, at the Municipal – Industrial Wastewater Treatment Plant in Oświęcim. Selected bacteria, the presence of which may indicate a potential threat to human health and the environment, were isolated from municipal, industrial and biologically treated wastewater. Quantitative and qualitative analyzes of selected microbiological sanitary indicators in the tested wastewater were performed using the standard serial dilution method, using selective growth media. The most numerous group of microorganisms in the treated wastewater were fecal streptococci. The applied activated sludge method reduced the number of *Shigella* bacteria to the highest degree.

Keywords: wastewater, activated sludge, indicator microorganisms.

ANALYSIS OF THE ENERGY EFFICIENCY OF A COMPRESSOR HEAT PUMP IN AN AIR-TO-WATER OPERATING SYSTEM

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Abstract

Growing requirements regarding energy consumption limitation and greenhouse gas emission reduction mean that air-to-water compressor heat pumps play an increasingly important role in modern heating systems. Their popularity results from simplicity of installation, availability of air as a lower source and the possibility of cooperation with low-temperature installations. The aim of the work was to evaluate the energy efficiency of an air-to-water heat pump during the start-up process, constituting a basis for further research on a hybrid lower heat source. The tests were performed on a 6.17 kW pump from GALMET, equipped with an inverter compressor and automatic refrigerant flow regulation. Measurements were conducted in the outdoor temperature range from -15°C to +15°C, and efficiency was determined based on the COP coefficient, defined as the ratio of thermal power to electrical power. The start-up analysis was performed for a buffer temperature of 50°C. Results showed that in the initial phase of the cycle COP reaches a value of about 4, whereas after stabilizing the temperature it drops to about 1.5. Energy used for defrosting constitutes 5-7% of the generated heat in the cycle. The highest efficiency was recorded in the first start-up cycle, while subsequent ones were characterized by several times smaller heat production with higher electricity consumption. The obtained results confirm the significant impact of start-up conditions on the efficiency of heat pump operation.

Keywords: air-to-water heat pump, energy efficiency, compressor heat pump, COP.

THE USE OF GREEN-BLUE INFRASTRUCTURE (GBI) ELEMENTS IN CIVIL PROTECTION IN THE ERA OF NATURAL AND GEOPOLITICAL THREATS

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Abstract

The study utilized an analysis of available source materials, including strategic documents, legal acts, reports of national and international institutions, and scientific publications on green-blue infrastructure, civil protection, and crisis management. Particular attention was paid to documents relating to adaptation to climate change, city resilience, and infrastructural security. Research methods included a comparative analysis of green-blue infrastructure solutions used in selected urban and suburban areas, indicating good practices possible to implement in domestic conditions. A qualitative analysis was also used, consisting of assessing the function and potential of individual elements of green-blue infrastructure in the context of mitigating the effects of natural and geopolitical threats. The research was supplemented by an analysis of spatial data and statistical information on environmental and infrastructural hazards, which allowed for an assessment of the relationship between the distribution of green-blue infrastructure elements and the level of population security. Based on the conducted analyzes, conclusions and strategic recommendations supporting the planning and decision-making process in the field of civil protection were formulated.

Keywords: green-blue infrastructure, spatial planning, extreme weather events, climate change.

COMPARATIVE ANALYSIS OF LANDFILL GAS COMPOSITION IN TWO DIFFERENT LANDFILL SITES WITH VARIABLE DECOMPOSITION OF MUNICIPAL WASTE

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Abstract

A comparative study of landfill gas variability in the years 2018-2023 in landfills with different periods of use and cessation of landfilling showed that the deposit remained in use for 18 years of the landfill and 4 years after closure in the phase of intensive methanogenesis. This is evidenced by the higher average values of CH₄ 56.7 % and CO₂ 24.1 % compared to the lower parameters of the gas in the repository, which was operated for 28 years and 22 years after its closure, which was characterized by a phase of unstable disappearing methanogenesis.

Aim: Comparative analysis of the composition of landfill gas generated at two municipal waste landfills in the years 2018-2023, differing in the degree of advancement of waste decomposition processes, in order to assess the impact of waste decomposition on landfill gas parameters, taking into account the operational and post-exploitation phases.

Methodology and scope of research: Landfill gas tests were carried out at wells and at the composition measurement point before the inlet to the installation. Measurements included determining methane (CH₄), oxygen (O₂), carbon dioxide (CO₂), and temperature and flow using a landfill gas analyzer. Frequency of landfill gas composition measurements A – semi-annually, B – quarterly.

Results: In the landfill A with a longer service life, the average temperature of landfill gas was higher by 12.6 °C and O₂ by 14.4 % compared to the landfill with a shorter service life B. By contrast, in landfill B, the average content of CH₄ was higher by 41.1 % and CO₂ by 14 %.

Conclusions: The results obtained confirm that the used landfill site for 28 years is 22 years after closure and remains in the phase of unstable methanogenesis transitioning into a silencing phase with a high oxygen content close to 20% and a low methane content of less than 20%. On the other hand, the landfill in use for a period of 18 years and 4 years after closure is in the phase of intensive methanogenesis, as evidenced by the content of over 50% methane and 30% carbon dioxide.

Keywords: landfill, mixed waste, degassing, reclamation.

ANALYSIS OF SELECTED ENVIRONMENTAL INSTALLATIONS SHAPING HUMAN WELL-BEING

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Abstract

The aim of the research was to analyze selected environmental installations shaping human well-being. A concept for the modernization of a former rural settlement into a contemporary summer recreation place was developed, a project for the modernization of water supply infrastructure for a camper field was carried out, and the benefits of using geophysics for locating underground utilities were discussed. As part of the research, a functional and spatial analysis of the facility was performed, along with the identification of the main design constraints resulting from its original construction and age; solutions were proposed to enable rational routing of water and sewage installations with minimal interference in the existing building structure; the existing state was inventoried – field conditions based on a basic map and technical analysis of existing collection points (site visit, photographic documentation), a water demand balance was made assuming an elevated standard of use and complete hydraulic network calculations, a technical design was made, including: designing the route of the water supply network in a ring system, selection of pipeline materials and shut-off, regulation and intake fittings and a connection node project to the existing supply installation; examples of the use of ground penetrating radar (GPR) in environmental engineering (locating underground infrastructure) as a helpful measuring tool were presented. Appropriate engineering solutions in a person's daily life are key determinants of well-being, directly affecting their physical health, psychological comfort and efficiency of use.

Keywords: environmental installations, project, human well-being, ground penetrating radar.

EVALUATION OF THE ENERGY EFFICIENCY OF A PUBLIC BUILDING

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Abstract

The evaluation of the energy efficiency of a building object is an important element of estimating and minimizing its operating costs. This analysis is of particular importance for objects with large volumes, including public utility buildings. The aim of the research was to determine the consumption of electricity and heat by a public utility building, i.e., a selected Municipal Office headquarters in the Silesian Voivodeship (Żywiec County). The scope of research included calculating the demand for: useful energy (EU), final energy (EK) and primary energy (EP) both before and after the thermal modernization carried out in the years 2016-2019, as well as developing recommendations for further modernizations aimed at reducing the energy intensity of the evaluated object. As a result of the analysis of energy indicators calculated for the building before and after thermal modernization, it was found that the construction work carried out had a positive impact on the energy and economic efficiency of this object, reducing primary energy consumption from 639.04 kWh·m⁻²·year⁻¹ to 143.83 kWh·m⁻²·year⁻¹. It is recommended to perform further work, as a result of which primary energy consumption can be reduced to 92.20 kWh·m⁻²·year⁻¹ (35.9%), which will allow for achieving the technical conditions provided for public utility buildings by 2030.

Keywords: thermal modernization, energy performance, energy efficiency.

CORRECTION OF DYNAMIC TEMPERATURE MEASUREMENT ERROR USING NUMERICAL THERMOMETER MODELS

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Abstract

The paper presents and verifies a method for determining the transient fluid temperature based on the temperature measurement in the axis of a solid cylinder-shaped thermometer, based on the solution of the inverse heat conduction problem. The research methodology included formulating a general model of the thermometer in the form of a solid cylinder using the finite volume method and developing a procedure for reconstructing the fluid temperature from the solution of the inverse problem. Three thermometer models were used: I, II and III order, covering respectively a model with lumped heat capacity and discretization of the cross-section into 2 and 3 control volumes. In order to verify the developed method, two tests were performed. In the computational test, the fluid temperature was determined based on temporal temperature changes measured in the axis of the cylindrical thermometer for a temperature jump from 20°C to 100°C and a known heat transfer coefficient α equal to 200 W/(m²K). The experimental test consisted of sudden immersion of the thermometer in a vessel with boiling water at a temperature of 99.3°C, and the average heat transfer coefficient on the external surface ($\alpha = 2980$ W/(m²K)) was determined using the least squares method. The analysis confirmed that the III-order model provides the highest accuracy of fluid temperature reconstruction. At the same time, models II and III showed a tendency to overestimate the temperature in the initial phase of the response, which indicates the importance of using digital filtration or selecting an appropriate computational step. The developed method is predisposed for on-line applications.

Keywords: industrial thermometer; measurement of high-pressure fluid temperature; mathematical model of a solid thermometer; inverse heat transfer problem; first, second and third order models; experimental research.

FEATURE SELECTION AND FORECASTING OF MUNICIPAL WASTE ACCUMULATION INDICATORS – A CASE STUDY OF THE SLOVAK REPUBLIC

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Abstract

The aim of the research was to assess the effectiveness of selected feature selection methods and predictive modeling techniques in forecasting the rate of municipal waste accumulation at the regional level, taking into account their usefulness for estimating the local energy potential of waste and planning energy recovery infrastructure. Six feature selection methods (BORUTA, LASSO, RFE, XGBoost, FSM and SEV) and five forecasting techniques were analyzed, including artificial neural networks (ANN), multivariate adaptive regression splines (MARS), rough set theory (RST), stepwise regression trees (SRT) and support vector machines (SVM). The study was based on socio-economic and demographic data from the Statistical Office of the Slovak Republic, covering 45 potential variables describing, among others, household structure, the labor market and energy consumption. In the first stage, the effectiveness of selection methods in identifying key predictors of the waste accumulation rate was assessed. The best results were obtained for the BORUTA, RFE and XGBoost methods, which indicated three dominant variables: the percentage of three-person households, the number of transport and warehouse enterprises per capita and the average nominal monthly wage. Predictive models were evaluated using MAE, MAPE, CV RMSE indicators and the R^2 coefficient of determination. The highest accuracy was achieved by MARS and ANN models with SEV selection ($R^2 > 0.88$) and the SVM model with XGBoost ($R^2 \approx 0.90$). Reducing the number of predictors to five resulted in only a slight decrease in accuracy, confirming the possibility of effectively forecasting waste streams with limited model complexity, important from the point of view of planning waste-to-energy systems and the circular economy.

Keywords: municipal waste potential, mass accumulation indicator of municipal waste, artificial intelligence methods, data selection, BORUTA, LASSO, RFE, XGBoost, FSM, SEV algorithm.

ANALYSIS OF THE FUNCTIONING OF THE SELECTIVE COLLECTION SYSTEM FOR BIODEGRADABLE KITCHEN WASTE ON THE EXAMPLE OF SELECTED COMMUNES OF THE SILESIAN VOIVODSHIP IN THE CONTEXT OF INCREASING RECOVERY AND RECYCLING LEVELS

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Abstract

Biodegradable kitchen waste has been separated as a distinct group of waste collected from households. Kitchen waste includes, among others: peelings and remains of fruits and vegetables, expired food products, dairy products, and food scraps. The article presents the state of functioning of the selective collection system at the source for biodegradable kitchen waste using the example of selected communes in the Silesian Voivodeship. An analysis was made of the percentage share of kitchen waste in the total stream of waste collected from a given commune, the methods of collecting kitchen waste depending on the type of development were determined, and their degree of contamination was verified. As a result of the analysis, it can be stated that the level of segregation at the source for biodegradable kitchen waste seems unsatisfactory. The waste is contaminated with numerous inclusions of plastics, glass, cans and other municipal waste. Kitchen waste is collected in brown containers or bags marked BIO, where it is thrown in plastic bags, whereas it should be collected loose. Such a high degree of contamination makes it difficult or even impossible to subject kitchen waste to further appropriate processing. Increasing the amount of kitchen waste segregated at the source could contribute to an increase in the level of recovery and recycling achieved in communes.

Keywords: waste collection, municipal waste, biodegradable kitchen waste, waste accumulation, recovery and recycling level, circular economy.

COMPARATIVE ANALYSIS OF HYDROGEN DRIVE TECHNOLOGIES IN PASSENGER VEHICLES IN THE CONTEXT OF SUSTAINABLE TRANSPORT

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Abstract

The analysis aimed to assess the energy efficiency, operating costs, emissions and technological conditions of FCEV and H₂-ICE drives, as well as their reference to classic combustion and electric drives in the conditions of the Polish energy mix. The analysis was based on a literature review, catalog data of selected vehicles and calculations of TTW and WTW indicators for the considered drives, using the assumed efficiencies of energy conversion stages to determine the total efficiency and the cost of traveling 100 km at current hydrogen prices in Poland.

The results indicate that the total WTW efficiency for FCEVs reaches approx. 60%, while for H₂-ICE it is approx. 35-38%, and the cost of traveling 100 km with consumption of 1.05 and 1.79 kg H₂ respectively is clearly lower for FCEV; additionally, FCEV consumes less fossil energy and emits significantly fewer greenhouse gases in the WTW cycle. The H₂-ICE engine retains the advantages of a simple, well-known construction, but its efficiency, operating costs and emissions (including NO_x) are less favorable and require extensive exhaust gas treatment systems.

Conclusions: The FCEV drive turns out to be more energy and economically efficient, while the H₂-ICE engine, despite its simpler construction and potentially cheaper production, loses competitiveness due to lower efficiency and higher fuel costs. In the coming years, it will be crucial to reduce the costs of hydrogen technologies, increase the share of green hydrogen, expand infrastructure and conduct further comparative analyzes for planning sustainable mobility.

Keywords: hydrogen drives; energy efficiency; sustainable transport.

WASTE OR RESOURCE? CHARACTERISTICS AND POSSIBILITIES OF REUSE OF APPLE POMACE AND ORGANIC WATER FROM CONCENTRATE PRODUCTION IN A CIRCULAR ECONOMY

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Abstract

The aim of the research work is an initial assessment of the potential for management of apple pomace and organic water generated in the apple concentrate production process. This waste, classified as waste from fruit processing with code 02 03 80 (pomace) and organic water, is generated in significant quantities, which constitutes a significant challenge in terms of its further management. Within the research, an initial analysis of the physicochemical properties of these raw materials was performed to determine the possibilities of their reuse as a source of valuable chemical compounds. Particular attention was paid to the potential application of the tested waste in the food, pharmaceutical, and cosmetic industries and in the energy sector, including as a raw material for fuel production. The conducted research aims to expand knowledge in the field of processing post-production waste and to indicate new directions for its use. The activities undertaken are in line with the assumptions of the circular economy, aimed at rational resource management and minimizing the amount of waste generated.

Keywords: circular economy, waste management, apple pomace, organic water.

DYNAMICS AND DIRECTIONS OF LAND COVER TRANSFORMATIONS IN POLAND IN THE LIGHT OF GLC_FCS30D SATELLITE DATA (1985-2022)

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Abstract

Changes in land use and land cover constitute an important factor shaping the functioning of the natural environment, affecting, among others, landscape structure, hydrological processes, and climatic conditions. In Poland, as in other Central European countries, the last decades have been characterized by intensive socio-economic transformations, the effects of which are reflected in land cover dynamics.

The aim of this study is the identification and quantitative assessment of land cover changes in Poland in the years 1985-2022 based on GLC_FCS30D satellite data with a spatial resolution of 30 m. The detailed GLC_FCS30D classification was generalized into ten main land cover classes, which allowed for the analysis of long-term area trends, dominant directions of transformation, and intensity of change, defined as the share of pixels changing land cover class in the total number of pixels of the analyzed area.

The results indicate systematic and spatially varied land cover changes in Poland. In the years 1985-2022, the area of agricultural land decreased by approx. 2.5 thousand km² (-1.4%), while simultaneously the area of anthropogenic areas increased by 3.5 thousand km² (+43%), which confirms long-term urbanization pressure. Significant transformations were also observed within forests. Coniferous forests decreased their area by approx. 4.0 thousand km², while deciduous forests increased it by approx. 2.7 thousand km², with the dominant direction of transformation being the conversion of coniferous forests into deciduous forests (approx. 3.9 thousand km²). The highest intensity of change was characteristic of highly urbanized regions, while the lowest values occurred in areas with a dominant share of forests and semi-natural areas. The conducted analysis confirms the high suitability of GLC_FCS30D data for studies of long-term land cover changes on a national scale and for monitoring key processes of landscape transformation in Poland.

Keywords: LULC, land cover transformations, change intensity, satellite remote sensing, GLC_FCS30D, Poland.

IMPACT OF ENVIRONMENTAL REGULATIONS ON CO₂ EMISSION INTENSITY IN THE EUROPEAN UNION GLASS INDUSTRY: AN ANALYSIS OF TRANSMISSION MECHANISMS

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Abstract

The aim of the research is an empirical assessment of the mechanisms through which environmental regulations affect CO₂ emission intensity in the glass industry in the European Union. In contrast to approaches assuming a direct regulatory effect or an indirect energy price channel, the study focuses on sequential testing of alternative transmission mechanisms, covering regulatory pressure, energy price changes, and structural-production factors. The analysis is based on an unbalanced panel dataset for EU countries in a country-year approach. Panel models were applied that take into account permanent differences between countries and common changes occurring over time. The dependent variable is CO₂ emission intensity, while key explanatory variables include a measure of environmental policy restrictiveness, electricity and natural gas prices, and an industrial activity indicator. The results do not confirm the existence of a direct impact of environmental regulations or a significant energy price channel. At the same time, a strong and stable influence of structural-production factors was demonstrated. The obtained results indicate that the reduction of CO₂ emission intensity in the glass industry is of a long-term nature and is primarily the effect of technological modernization processes and structural changes, rather than short-term regulatory pressure.

Keywords: environmental regulations, CO₂ emissions, glass industry, energy prices, panel analysis, European Union.

POSSIBILITIES OF MANAGEMENT OF WASTE BIOMASS FOR FERTILIZER PURPOSES

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Abstract

The increasing amount of organic waste poses challenges for waste management and agriculture, while simultaneously constituting a potential source of nutrients for plants. The aim of the work was to evaluate the possibilities of waste biomass management by determining the impact of its processed form on the growth and development of pepper seedlings (*Capsicum annum* L.). In the experiment, three types of compost (A, B, C) were used in different proportions in substrates for transplant production, along with a control variant without the addition of compost. Seedling growth parameters were monitored, including root and stem length, number of leaves, leaf area, and fresh and dry weight. Results showed that the best biometric parameters were achieved in substrate A(I), even though it contained only 25% compost addition, which indicates that seedling growth was not directly dependent on the nutrient content in the substrate. The application of various composts did not significantly affect the fresh and dry weight of plants, while the slow conversion of ammonium nitrogen to nitrates limited the development of leaf area. The study confirms that processed waste biomass can effectively support plant growth and constitute a valuable addition to cultivation substrates, in line with the principles of sustainable agriculture and the circular economy.

Keywords: waste biomass, compost, pepper, cultivation substrates, plant growth, organic fertilizers.

BALANCE AND ASSESSMENT OF THE SUITABILITY OF SELECTED WASTES AS SUBSTRATES FOR BIOGAS PRODUCTION

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Abstract

Along with the development of technology and the growing demand for renewable energy sources, the use of organic waste as energy raw materials is becoming increasingly important. Biodegradable municipal waste constitutes a valuable source of carbon and hydrogen, which in the methane fermentation process can be converted into high-energy biogas. The paper presents the concept of a biogas plant using various biodegradable wastes, based on computer simulations and balance calculations. Eight different substrate mixtures were analyzed, covering, among others, frying fat, expired food, bio-waste from households, kitchen waste, vegetable waste from marketplaces, and sewage sludge. The results obtained allowed for the assessment of the suitability of individual waste streams and the preparation of an energy balance for the proposed combinations. The potential for their use in combined heat and power (CHP) systems, enabling simultaneous generation of electricity and heat, was indicated, which may contribute to increasing the energy efficiency of the installation and improving the profitability of the process. The conducted analyzes emphasize the importance of sustainable substrate selection in the biogas production process and indicate broad possibilities for effective management of organic waste on a communal and industrial scale, while simultaneously reducing the negative impact on the environment.

Keywords: biodegradable waste, biogas, biogas plant.

FROM WASTE TO VALUE: UPCYKLING STALE BREAD AND APPLE POMACE INTO A FUNCIONAL SNACK

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Abstract

The aim of this project was to develop a functional food prototype based on the upcycling of local food waste streams, specifically stale bread and apple-derived by-products, contributing to sustainable and circular food systems. The developed prototype consisted of baked and dried balls produced from stale bread enriched with apple pomace and coated with a functional layer. The coating system was formulated using amidated apple pectin and honey, cross-linked with calcium ions, and finished with a dry outer layer of freeze-dried apple peel powder. Sensory evaluation was carried out using a 9-point hedonic scale, indicating good overall consumer acceptance. High scores were obtained for appearance (7.6) and color (7.4), while taste, considered the most important attribute, reached a mean value of 6.8. Protein content was determined using the Bradford method, vitamin C by iodometric titration, and antioxidant activity was assessed using FRAP and DPPH assays. The moist sample exhibited approximately 2.5-fold higher reducing power and greater free radical scavenging capacity compared to the dried sample. Overall, the results demonstrate that upcycling bakery surplus and fruit processing by-products enables the development of a functional food with moderate to high in vitro antioxidant potential. Bioactive compounds derived from apple pomace, apple peel, honey, and pectin contribute to metal ion reduction and free radical scavenging, confirming valuable functional properties. The applied upcycling strategy transforms low-value food waste into a nutritionally enriched product while supporting food waste prevention, resource efficiency, and circular economy principles.

Keywords: food waste, upcycling, bread, apple, functional snack.

OPTIMIZATION TECHNOLOGY FOR WASTE OIL REGENERATION PRODUCTS AS AN ELEMENT OF THE CIRCULAR ECONOMY

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Abstract

Oils perform an important function in many areas of human activity, especially in technological areas. They are used as lubricants, hydraulic or cooling agents. However, during operation, they lose their physicochemical properties, which affects the quality and reliability of devices. As a result, hazardous waste is generated, which requires processing in recycling processes. The article will present a regeneration process that allows for the recovery of the functionality of the used medium, while reducing the environmental impact of the processes used so far. The aim of the article will be to present a technology that aims to improve the quality of the products obtained and their full reuse, reducing the environmental impact and the amount of waste generated. An extremely important aspect of innovative re-refining technologies is to prove the environmental advantage of regeneration and base oil recovery over traditional extraction from crude oil.

Keywords: oils, lubricants, recycling, circular economy.

ANALYSIS OF THE EFFECTIVENESS OF WASTEWATER TREATMENT IN THE CZORSZTYN LAKE REGION

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Abstract

The aim of the research in this work was to analyze the effectiveness of wastewater treatment in 15 wastewater treatment plants in the Czorsztyn Lake region, which serves as an indirect and direct receiver of treated wastewater from these facilities. The analyzed wastewater treatment plants are located in: Czarny Dunajec, Czorsztyn, Dębno, Frydman, Kluszkowce, Krempachy, Krościenko, Łopuszna, Maniowy, Niedzica, Sromowce Niżne, Sromowce Wyżne, Szczawnica, Trute and Trybsz. The evaluation of wastewater treatment effectiveness in these facilities was made based on calculations of the average reduction degree (η) of selected pollution indicators (BOD₅, COD_{Cr}, total suspended solids, total nitrogen and total phosphorus) and an analysis of the number of exceedances of their permissible values in treated wastewater. The evaluation of the work of the tested treatment plants was based on research results from two years (2023-2024). High effectiveness of wastewater treatment was found in the case of BOD₅, COD_{Cr}, and total suspended solids (reduction range of the analyzed pollutants was respectively: $\eta_{\text{BOD5}} = 91.2\% - 99.1\%$, $\eta_{\text{CODCr}} = 80.9\% - 96.7\%$, $\eta_{\text{ts}} = 88.5\% - 98.3\%$). For total nitrogen, the average reduction effectiveness ranged from 48.2% to 96.6%, and for total phosphorus from 55.6% to 95.7%. Exceedances of total nitrogen permissible values were found in 40% of the tested samples at the wastewater treatment plant in Niedzica and one-time exceedances of total phosphorus in Czarny Dunajec, Czorsztyn and Niedzica.

Keywords: wastewater treatment plant, treatment effectiveness, pollution reduction degree.

ENERGY TRANSFORMATION PROCESS BASED ON THE EXAMPLE OF MPEC NOWY SĄCZ

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Abstract

The aim of this paper is to present a practical model of energy transformation implemented by MPEC Nowy Sącz, a municipal district heating company operating in southern Poland. The analysis is based on the development path presented for 2025, when the company supplied heat through a 65 km network to 619 facilities, with ordered power of 85 MW and 17.2 MW of installed capacity in renewable energy sources and cogeneration. The case study shows that the transformation of a local heating system requires simultaneous organizational, financial, technological and environmental actions.

The transformation process was structured according to the A-B-C-D-E approach: activation, budget, digitalization, diversification and ecology. Activation covered the engagement of employees, the establishment of a Strategic Investment Committee, project coordinators, a competence development centre and an internal innovation programme. Budgetary activities focused on obtaining external financing for network modernization, biomass installations, high-efficiency cogeneration, energy storage and digital transformation. In 2019-2026, projects financed from external funds reached PLN 127.5 million, supplemented by PLN 54.0 million of cogeneration bonuses for Nowy Sącz and Stary Sącz.

Digitalization included the implementation of a supervisory SCADA system, monitoring of heating networks and substations, electronic document circulation, electronic boiler-house reports, brigade management and facility management. Additional solutions were introduced for biomass logistics, including 3D measurement of wood chips and the KZR INiG certification system. Diversification of heat generation was based on reducing dependence on coal and developing biomass, gas-fired high-efficiency cogeneration and auxiliary gas-oil sources. As a result, the non-renewable primary energy factor decreased from 1.49-1.50 in 2019-2020 to 0.74 in 2024-2025.

The implemented measures translated into measurable environmental effects. Compared with a scenario based entirely on coal, the current generation mix reduces dust emissions by 31% and CO₂ emissions by 40%. The MPEC Nowy Sącz example confirms that municipal heating companies can conduct energy transformation effectively when investment planning, employee activation, digital tools and source diversification are treated as mutually reinforcing elements of one strategic process.

Keywords: energy transformation, district heating, cogeneration, biomass, digitalization, environmental effects.

ENVIRONMENTAL DECISION SUPPORT SYSTEM FOR RENEWABLE ENERGY SOURCES IN LOCATION COMPLIANCE ASSESSMENT AND SPATIAL-NATURAL CONFLICT REDUCTION

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Abstract

The aim of this study was to develop and verify an original Environmental Decision Support System for renewable energy sources, focused on location compliance assessment and reduction of spatial and natural conflicts. The work addresses the growing need for stable renewable energy sources, including agricultural biogas plants, and the increasing complexity of legal, environmental, technical and social conditions that must be considered at the planning and preliminary design stages. The core of the proposed solution is the Dynamic Boundary Conditions Generation System, integrating geoinformation data, artificial intelligence, natural language processing and an expert knowledge base. The system collects, updates and transforms heterogeneous information, such as legal provisions, environmental quality indicators, energy demand, emissions, technical parameters of installations and spatial constraints. A hybrid agent architecture enables interpretation of user queries, detection of missing data and conversion of verified requirements into operational rules for geospatial analysis. The methodology included the development of the conceptual system architecture, dynamic training of the LLM model, semantic analysis of input queries, spatial data processing and the use of a multi-criteria hierarchical cluster analysis method. Verification was carried out for the City of Nowy Sącz and the Municipality of Stary Sącz. The knowledge base was extended with local planning regulations and environmental constraints, including distance relations, landslide risk and forms of nature protection relevant to renewable energy investments. The results confirmed that legal regulations, spatial data and expert knowledge can be integrated in one computational environment, producing clear, repeatable and auditable location assessments. The system supports data quality control through the materiality principle, change detection in legal sources and expert verification. Compared with a classical geoinformation approach, the indication of an optimal renewable energy location was completed in approximately 22 minutes. The solution supports local governments, investors and design offices in planning photovoltaic, wind and biogas projects, including hybrid energy systems, and its implementation potential was demonstrated in applications for SOLGRO and Pracownia Projektowa Pawlak in Nowy Sącz.

Keywords: renewable energy sources, environmental decision support, geoinformation, artificial intelligence, spatial planning, location compliance, biogas plants, photovoltaics.

INTEGRATED MODEL FOR SHAPING EMISSIONS IN ROAD TRANSPORT: VEHICLE DIAGNOSTICS, EXHAUST ANALYSIS, AND USER BEHAVIOR

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Abstract

Road transport has a significant impact on the environment, while the level of emissions depends not only on vehicle technology, technical condition and combustion processes, but also on everyday decisions made by users. The aim of the study was to determine the extent to which pro-environmental attitudes and practices related to vehicle maintenance and driving style translate into actual energy-saving and environmentally responsible transport behaviors among residents of the mountainous areas of the Małopolska region.

The study was based on a quantitative survey conducted among 423 active passenger-car users from six mountainous districts of Małopolska. The original questionnaire covered demographic characteristics, pro-environmental attitudes, energy-saving practices, vehicle maintenance and driving style. The collected data were analyzed using non-parametric tests, Spearman correlations and principal component analysis.

The results showed that most respondents declared at least one pro-environmental activity, although sustainable transport behaviors were usually limited to one or two actions. Around half of the participants reported energy-saving practices, and a similar share considered replacing their car with a more environmentally friendly or fuel-efficient vehicle. The highest level of such declarations was observed in the 25-44 age group, while the lowest was recorded among users under 25 years of age. The findings indicate that energy-saving activity and motivation to replace a vehicle are positively associated with sustainable transport behaviors.

The study confirms that effective reduction of road-transport emissions requires an integrated approach combining technical diagnostics, exhaust analysis and behavioral interventions. Particular attention should be paid to education and support measures targeted at younger drivers, who demonstrated the lowest level of pro-environmental behaviors.

Keywords: road transport emissions, vehicle diagnostics, user behavior, energy-saving practices, sustainable transport.

INTEGRATING RENEWABLE ENERGY INTO SUSTAINABLE TRANSPORTATION: PROPULSION TECHNOLOGIES AND ENERGY TRANSITION MECHANISMS

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Abstract

The decarbonization of transportation is one of the key challenges of the current energy transition, as growing demand for mobility and the sector's heavy reliance on fossil fuels necessitate the implementation of modern propulsion technologies. The aim of this study was to analyze the role of electric, hybrid, hydrogen, and biofuel vehicles in reducing fossil fuel consumption and greenhouse gas emissions in the transportation sector.

The study was a review and was based on an analysis of scientific literature from 2019-2025, identified in the Scopus, Web of Science, and Elsevier databases. Selected publications were subjected to thematic analysis to identify the most important trends, limitations, and opportunities for the development of technologies supporting the decarbonization of transport.

The results indicate that battery-electric vehicles are the most energy-efficient, with energy consumption of approximately 18-20 kWh/100 km, while internal combustion engine vehicles require approximately 60-70 kWh/100 km. Electric vehicles also demonstrate the greatest potential for reducing CO₂ emissions over their lifecycle, estimated at approximately 60-70%, and with a high share of renewable energy sources in the energy mix, even up to approximately 80%. Hybrid technologies can serve as a transitional solution, enabling a partial reduction in emissions while utilizing existing infrastructure.

Hydrogen and advanced biofuels are particularly important in sectors that are difficult to fully electrify, such as heavy-duty, maritime, and aviation transport. However, their implementation is limited by high costs, lower overall efficiency in the case of hydrogen technologies, and limited availability of sustainable feedstocks for biofuel production. Effective decarbonization of transport therefore requires the complementary use of various propulsion technologies, tailored to the specific characteristics of individual transport segments, infrastructure availability, the emissions profile of the energy mix, and regulatory conditions.

Keywords: decarbonization of transportation, renewable energy sources, propulsion technologies, electric vehicles, biofuels.

THE IMPORTANCE OF VEHICLE GEOMETRY IN ENSURING ROAD TRAFFIC SAFETY DURING VEHICLE APPROVAL AFTER COLLISIONS AND ACCIDENTS

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Abstract

The presentation discusses the role of vehicle geometry in ensuring road traffic safety, particularly during the process of approving vehicles for road use after collisions and accidents. It focuses on the main parameters of wheel geometry, including toe-in/toe-out, camber angle and caster angle, which directly influence vehicle stability, steering precision, tire wear and overall driving safety. The presentation explains that incorrect wheel geometry may lead to several symptoms, such as uneven tire wear, difficulties in vehicle handling, unusual sounds from the suspension system and increased fuel consumption. For this reason, geometry inspection should be treated as an important diagnostic procedure, especially in vehicles that have been involved in road incidents. The methodology presented includes proper preparation of the vehicle for measurement: checking tire pressure, verifying tire size, loading the vehicle according to the manufacturer's instructions and positioning it correctly on a diagnostic stand, with the front axle placed on turntables and the rear axle on sliding plates. The case studies presented in the slides show examples of vehicles subjected to geometry assessment after damage or suspected suspension irregularities. The diagnostic process combines visual inspection of wheels, rims, suspension elements and hubs with professional wheel alignment measurements. The analysis confirms that even local damage to suspension or wheel components may cause deviations in vehicle geometry parameters, which can reduce driving stability and compromise road safety. Therefore, wheel geometry diagnostics should be an integral part of post-accident vehicle assessment. Accurate measurement and interpretation of geometry parameters support reliable decisions on whether a vehicle can be safely returned to road traffic after repair.

Keywords: vehicle geometry, wheel alignment, road safety, post-accident diagnostics, vehicle inspection.

EFFECTIVE TESTING METHODS IN IT SYSTEMS FOR ENVIRONMENTAL QUALITY MONITORING

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Abstract

Information systems used to monitor, manage, and analyze environmental data play a vital role in environmental protection. For this reason, the quality and security of the software developed are essential to ensuring effectiveness and operational continuity. However, these systems are often exposed to various risks, including failures, software defects, unauthorized access, and large volumes of data. For this reason, an important element of risk management is the use of appropriate testing methods and effective IT security measures. The scientific objective of this article is to answer the question of what are the most effective testing methods in IT systems for environmental monitoring, what benefits and limitations each method has, how they contribute to minimizing environmental risks, which methods are overlooked, and what risks such an approach entails. Furthermore, the IT security of these systems will be evaluated in terms of best practices and current trends. The collected information will be analyzed, and recommendations will be prepared for the implementation of the examined methods in risk management.

Keywords: regression test automation, IT systems, air emissions, cybersecurity, environmental risk management.

ANALYSIS OF STREET SWEEPINGS FRACTIONS USING MICROSCOPIC METHODS

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Abstract

The aim of the street sweepings study was to classify them into grain size fractions using visual methods, specifically stereoscopic microscopy and scanning microscopy. The elemental composition of seven street sweepings samples was analyzed using an X-ray energy dispersive spectrometer. The samples examined had the following morphological characteristics: quartz grains of approximately 0.5 mm in size, fine grains smaller than 0.1 mm, and street dust consisting of particles 30 µm in size embedded in a matrix of particles smaller than 10 µm. The ultrafine dust consisted of particles approximately 0.5 µm in size. The highest concentrations of iron and calcium were found in the fine street sweepings fraction (below 0.1 mm). Apart from chromium, manganese, and a single measurement of zinc in particles smaller than 100 µm, no heavy metals were detected in electron-microscopic samples. Understanding the sources of chromium is crucial for developing effective street sweeping strategies. Microscopic studies confirm that street sweepers are capable of wet-collecting the finest street dust.

Keywords: street sweepings, scanning electron microscopy, particle size fractions, elemental composition.

AUTONOMOUS RENEWABLE-ENERGY-POWERED ALARM SYSTEM: SELECTION OF SOURCES, STORAGE AND LOW-POWER ELECTRONICS

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Abstract

Autonomous alarm systems are particularly important in dispersed facilities requiring continuous monitoring, such as pumping stations, telemetry stations and elements of critical infrastructure. In such locations, the reliability of alarm detection and event transmission may be limited by interruptions in grid power supply or the lack of cable infrastructure. The use of renewable energy sources enables the development of an independent alarm system capable of maintaining operation under field conditions and with very low power consumption.

The aim of the study was to present a methodology for selecting and dimensioning a renewable-energy-powered autonomous alarm system, including energy sources, energy storage and low-power electronic components. The proposed approach takes into account the energy profile of the system in standby, alarm and transmission modes, seasonal variability of renewable energy production, winter yield, shading conditions, battery capacity, charging controller type and environmental resistance requirements.

The design assumptions included year-round operation in Polish climatic conditions, 3-7 days of autonomy without energy production from renewable sources, ultra-low-power standby mode, alarm event peak power of 10-30 W, and communication using LTE-M, NB-IoT or LoRaWAN technologies. A sample configuration included an 80-120 Wp photovoltaic panel, an MPPT controller, a 12 V / 20-30 Ah LiFePO₄ or AGM battery, DC/DC converters, low-power MCU, sensors and a communication module.

The analysis indicates that the correct selection of renewable energy sources should be based on the daily energy balance and the availability of resources in the least favorable months. The energy storage system should be dimensioned according to the required autonomy, permissible depth of discharge and operating temperature. The greatest energy savings can be achieved by optimizing standby consumption through MCU sleep modes, duty-cycling of sensors and modems, and separating the high-power alarm signaling circuit from the control electronics.

Keywords: autonomous alarm system, renewable energy sources, energy storage, low-power electronics, photovoltaic power supply.

THE WATER RAM AS AN ECO-FRIENDLY METHOD OF FIELD IRRIGATION – AN ANALYSIS USING THE FEM

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Abstract

In light of growing water scarcity issues and the need to reduce conventional energy consumption, there is a demand for solutions that enable environmentally friendly and self-sufficient irrigation of agricultural land. One such solution is the hydraulic ram, which utilizes the phenomenon of hydraulic shock to transport water to a higher elevation without an external power source. This paper presents a comprehensive analysis of the operation of a water ram designed for irrigating areas located near mountain watercourses. Particular emphasis was placed on numerical flow modeling using the finite element method (FEM) in the ANSYS environment. The developed three-dimensional CFD model enabled a detailed assessment of velocity distributions, pressure losses, and local vortices in key system components, such as the impact valve and check valve. The analysis of computational mesh independence allowed for the optimal selection of discretization parameters, ensuring a balance between the accuracy of results and computation time. The simulation results were validated by experimental studies conducted on an actual facility that has been operating continuously for several years. The achieved capacities of several hundred liters of water per day demonstrate that a water ram can be an effective, low-emission, and practical solution to support field irrigation in areas with limited access to electricity.

Keywords: hydraulics, water ram, irrigation, simulation, ANSYS, low-carbon, renewable energy.

THE CODE THAT BRINGS TO LIFE

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Abstract

The development of humanoid robotics and artificial intelligence has led to the emergence of systems capable of increasingly advanced human interaction and adaptation to dynamic environments. The paper “The Code That Brings to Life. Artificial Intelligence in the World of Humanoid Robots: From Theory to Interaction” presents contemporary applications of artificial intelligence in humanoid robotics using the Unitree G1 robot as an example of the integration of intelligent algorithms with a real-world physical system. The discussion begins with an analysis of the evolution of robot representations – from fictional visions in popular culture to modern constructions capable of functioning in social and practical environments. Particular attention is devoted to the fundamental areas of artificial intelligence, including AI, machine learning, and deep learning, which enable robots to perceive their surroundings, make decisions, and perform autonomous actions. The paper also discusses key mechanisms responsible for environmental perception, motion planning, and human–robot interaction, including speech recognition and natural language processing. Furthermore, selected technologies supporting the integration of perception, communication, and control systems are outlined. It is argued that the development of humanoid robots represents a new direction in human–machine collaboration, creating a bridge between advanced code and physical reality.

Keywords: humanoid robotics, artificial intelligence, machine learning, human–robot interaction, natural language processing.

FRictional INTERPRETATION OF HYBRID PEUSNER COEFFICIENTS IN THE KEDEM-KATCHALSKY-PEUSNER EQUATIONS FOR LIQUID INTERFACE POTENTIALS IN A SINGLE-MEMBRANE SYSTEM

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Abstract

Onsager-Peusner Network thermodynamics (PNT) is one of the most important formalisms describing the membrane transport. A procedure for transforming the Kedem-Katchalsky (K-K) equations for the transport of binary electrolyte solutions through a membrane into the Kedem-Katchalsky-Peusner (K-K-P) equations within the PNT framework was elaborated. A hemodialysis membrane (Ultra Flo 145 Dialyser) and aqueous NaCl solutions were used. The P version of the K-K-P formalism for binary electrolyte solutions was used for the analysis. The Peusner coefficients obtained from the transformation of the K-K formalism coefficients for the transport of electrolyte solutions were used to calculate the coupling coefficients of membrane processes and the dissipative energy flux. The dissipative energy flux as a function of thermodynamic forces allows to determine the energy conversion of transport processes in the membrane system. The Peusner coefficients were also expressed in terms of friction coefficients, taking into account the interaction of the transported substances with each other and with the membrane structure.

Keywords: Kedem-Katchalsky-Peusner model, polymer membrane, Peusner coefficients, transport through membrane, energy conversion, entropy of membrane processes.

SUSTAINABILITY MANAGEMENT: UPSTREAM'S STRATEGY TO COMBAT SYSTEMIC RESOURCE WASTE

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Abstract

One of the most pressing challenges of our time is to reduce waste generation and manage waste properly in order to minimize – and ultimately eliminate – the waste of resources and energy, as well as the negative impact of waste on the environment, human health and life, and economic processes. The scale of the problems facing modern civilization is evidenced by the amount of waste generated, which globally amounted to approximately 2.1 billion tons in 2023, as well as the observed upward trend, according to which this figure is projected to reach 3.40 billion tons by 2050. One of the many tools for implementing the goal of reducing the amount of waste generated and ensuring its proper management are strategies for managing the sustainability of manufactured and distributed products. By implementing various measures aimed at extending a product's life cycle during its use phase, it is possible in many cases – though it should be emphasized that this is not true in all cases – to reduce the amount of waste generated. Such measures clearly bear the hallmarks of an upstream strategy, whose primary goal is to prevent problems before they occur and to address them at their source, in contrast to measures focused on a downstream approach, which can be described as symptomatic. The aim of this presentation is to review the strategies for product sustainability management currently found in the scientific literature, encompassing both dual-pronged measures that may contribute to shortening a product's life cycle during its use phase, as well as approaches leading to its extension. In the author's opinion, measures focused on ensuring greater product durability should form the core of efforts aimed at reducing the amount of waste generated.

Keywords: waste management, product sustainability, product life cycle, product durability, circular economy.

AI AND THE IMPLEMENTATION OF THE SUSTAINABLE DEVELOPMENT GOALS AND THE 5P MODEL

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Abstract

Sustainable development is one of the key directions of contemporary global policies and socio-economic strategies. The United Nations 2030 Agenda defines 17 Sustainable Development Goals aimed at balancing economic growth, social well-being and environmental protection. These assumptions are reflected in the 5P model: People, Planet, Prosperity, Peace and Partnership, which emphasizes the need for an integrated and responsible approach to global development.

The aim of the study was to present the potential impact of artificial intelligence on the implementation of sustainable development objectives in the context of the 2030 Agenda and the 5P model. The analysis focused on both the opportunities offered by AI technologies and the challenges resulting from their dynamic development. The poster has a review and analytical character and is based on scientific literature and reports of international organizations, including the United Nations, OECD, International Energy Agency and European Commission.

The analysis indicates that artificial intelligence can support the implementation of sustainable development goals in social, environmental and economic areas. AI may improve healthcare, education and public services through data analysis and process automation. It can also support climate monitoring, energy management, resource optimization, innovation and global scientific cooperation. At the same time, the development of AI generates significant challenges related to increasing energy consumption, the environmental footprint of digital infrastructure, digital inequalities, ethical risks, disinformation and the concentration of technological power.

The study concludes that artificial intelligence may become an important tool supporting the implementation of the 2030 Agenda, provided that it is developed and applied responsibly. Its final impact on sustainable development depends on international cooperation, inclusive access to technology, improved energy efficiency and the creation of appropriate ethical, legal and social frameworks for AI governance.

Keywords: artificial intelligence, Sustainable Development Goals, Agenda 2030, 5P model, responsible innovation.

CIRCULAR BIOWASTE MANAGEMENT: THE ROLE OF BIOGAS PLANTS IN REGIONAL CIRCULAR ECONOMY SYSTEMS

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Abstract

Biowaste constitutes an important stream of municipal and agricultural waste, and its proper management is essential for reducing environmental pressure, greenhouse gas emissions and the inefficient use of resources. Contemporary waste management systems are increasingly shifting from a linear model towards solutions based on circular economy principles, where organic waste is treated as a valuable resource that can be reused in energy and material cycles.

The aim of this study is to present the role of biogas plants in circular biowaste management and to assess their importance in regional circular economy systems. Particular attention is paid to the use of biowaste as a substrate for biogas production, electricity and heat generation, and digestate recovery. Digestate may support nutrient recycling and contribute to closing the organic matter loop at local and regional levels.

Biogas plants can integrate several sectors, including agriculture, municipal waste management, energy and environmental protection. Their development supports regional energy security, reduces dependence on fossil fuels and improves the efficiency of organic waste stream management. However, effective implementation requires appropriate site selection, stable substrate supply, social acceptance and technological solutions adapted to regional conditions.

The analysis indicates that biogas plants may become an important component of regional circular economy systems by combining environmental, energy and economic objectives. Their successful development requires cooperation between local governments, enterprises, the agricultural sector and residents, as well as the creation of local biowaste management models based on resource efficiency and the reduction of environmental losses.

Keywords: biowaste, biogas plants, circular economy, energy recovery, regional waste management.

EMISSIONS FROM THE GLASS INDUSTRY IN THE EU

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Abstract

The glass industry is an energy-intensive sector and remains a significant source of greenhouse gas emissions in the European manufacturing sector. In the context of EU climate policy, rising energy costs, and tightening regulations (including those under the EU ETS), understanding the long-term changes in the industry's emissions profile is crucial. The aim of this study was to answer the question: "How does the emissions profile of the glass industry in the EU change over time?" An analysis of the glass production process was conducted, with particular emphasis on the technologies used and the emissions generated by the industry (including CO₂, NO_x, and SO_x). Subsequently, an analysis of data provided by Eurostat was performed. The average emissions intensity of the glass industry in the EU is on a downward trend due to improved furnace efficiency, a higher share of cullet, and gradual electrification and fuel switching. In post-2020 ETS data, industrial emissions are significantly lower than in 2014, and the declines after 2022 were further amplified by lower production during the energy crisis. Despite the long-term overall downward trend, however, an increase in emissions can be observed in some years on a year-over-year basis.

Keywords: emissions, CO₂ emissions, glass industry, European Union.

ANALYSIS OF THE EFFECTIVENESS OF LANDFILL BIOGAS PURIFICATION IN THE PROCESS OF ENERGY AND WASTE PRODUCTION IN A COGENERATION PLANT

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Abstract

Landfill biogas, which is produced in the waste deposit at a landfill, poses a threat to the environment and human health. In this regard, it is important to capture, treat, and safely neutralize or utilize it. The aim of this study was to conduct research to determine the types of contaminants in landfill biogas and the actual effectiveness of hydrogen sulfide removal from biogas during the treatment process. The qualitative analyses of raw and treated landfill gas conducted in this study revealed significant exceedances of hydrogen sulfide, reaching 304.1 ppm relative to the requirements of gas engine manufacturers, while the calculated hydrogen sulfide reduction efficiency was 24.58%. Examinations of the surface of the spent carbon and its pores using a scanning electron microscope revealed significant clogging by sulfur compounds, which prevents proper reduction of this compound and reduces the efficiency of the purification system. Replacement of the activated carbon bed resulted in a hydrogen sulfide concentration of 7.5 ppm in the treated gas, and the calculated reduction efficiency was 97.9%. The test results confirmed the necessity of continuous monitoring of biogas quality, as well as the validity of using impregnated activated carbon for hydrogen sulfide removal, including its high adsorption efficiency. This solution ensures the reliable operation of the gas engine in the cogeneration unit and improves the efficiency of electricity and heat production in the system.

Keywords: landfill biogas, biogas treatment, activated carbon, cogeneration, circular economy.

ANALYSIS OF THE ENVIRONMENTAL ASPECTS OF METHANE EMISSIONS FROM LANDFILLS – EMISSIONS REPORTING AS A TOOL FOR MONITORING AND MITIGATING CLIMATE CHANGE

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Abstract

Uncontrolled methane emissions into the atmosphere from landfill biogas represent a quantitatively significant but untapped source of renewable energy. Such emissions have serious public health consequences and contribute to reduced yields in agricultural and forest ecosystems. In Poland, the emissions control system includes the National Pollutant Release and Transfer Register (PRTR), which is part of the European Pollutant Release and Transfer Register (E-PRTR). The main objective of this study is to conduct a methane emissions inventory, assess the effectiveness of monitoring, and evaluate the level of fees for atmospheric emissions in relation to the social impacts they cause. The results of the emissions analysis showed average annual methane emissions in Poland for the years 2019-2023 at 10,672.03 Mg and associated fees of 3,376.41 PLN. The economic aspects of methane emissions, which form the basis for the financial burden on landfill operators in Poland, do not directly correlate with the social costs caused by these methane emissions. The average annual environmental fee paid by landfill operators amounted to PLN 0.31/MgCH₄, while the social impacts were estimated at PLN 716/MgCH₄. Current environmental policy does not provide mechanisms to encourage companies to implement measures to reduce methane emissions. In this context, it is recommended that systemic changes be introduced—in particular, strengthening control mechanisms, ensuring transparent methods for determining actual methane emission levels, and establishing clear thresholds for exceeding permissible limits.

Keywords: methane emissions, landfill gas, renewable energy, sustainability.

CARBON IN ORGANOGENIC SOILS IN POLAND

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Abstract

Peatlands cover approximately 4% of Poland's area, but about 85% of them have been drained and are used mainly for agriculture, particularly as grasslands. The aim of the study was to assess changes in organogenic soils in Poland over nearly 50 years of agricultural management, with particular focus on changes in the depth of the soil organic carbon-rich layer, soil organic carbon content and carbon stock under different land-use types and drainage conditions.

The study was based on a comparison of 476 pairs of reference soil profiles surveyed in 1975 and 2017. The analyzed soils were classified as soils of organic origin, including peat, peat-mursh, murshic, peaty mud, muddy peat, semimurshic and postmurshic soils. The research included measurements of the depth of the SOC-rich layer and SOC/SOM content. Soil organic carbon stocks were calculated, and a generalized linear mixed model was applied to evaluate the relationship between soil properties and variables such as year and soil group.

The results showed that after nearly 50 years, the SOC content in organogenic soils was reduced by almost half and this decrease was observed in 70% of the studied sites. The depth of the SOC-rich layer decreased by approximately 8 cm. A decrease in SOC stock was recorded in 64% of sites, while an increase was observed in 36%; however, the increase was more than twice smaller than the losses. The highest SOC stock losses were found in organic soils and in soils with a deep SOC-rich layer.

The study indicates that continuous grassland management of organic soils over nearly five decades does not compensate for SOC losses caused by soil organic matter oxidation resulting from drainage. In contrast, smaller SOC stock losses observed in organo-mineral and mineral soils suggest that these soils may maintain a more stable balance between carbon inputs and outputs.

Keywords: organogenic soils, soil organic carbon, peatlands, carbon stock, agricultural drainage.

APPLICATION OF THE LCA METHOD IN ASSESSING THE ENVIRONMENTAL IMPACT OF POLYMER FLOCCULANTS

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Abstract

Plastic waste is modified through various chemical processes to be used in the production of new products. Through chemical modification, it is possible to reduce the negative impact of this waste on the environment, as well as to preserve valuable natural resources. In recent years, the amount of plastic waste has been increasing, and under the principles of waste management and legal requirements applicable in European Union countries, it is necessary to strive to maximize waste recycling and reuse. Currently, the environmental impact of new products is analyzed using the Life Cycle Assessment method. The purpose of this study was to estimate the life cycle of a flocculant synthesized from phenol-formaldehyde resin waste, an amine derivative of phenol-formaldehyde resin used to assist in the coagulation of mine waters. Due to the amount of polymers waste in the environment and its toxic effects, as well as for the sake of caring for natural resources, it is reasonable, according to current regulations in European Union countries.

Keywords: Life cycle assessment (LCA), polymers waste, flocculant, energy-related emissions, industrial wastewater.