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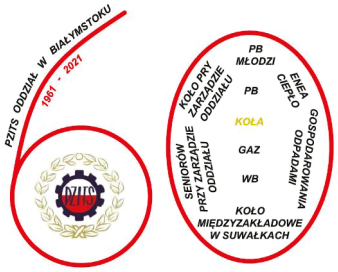
XI INTERNATIONAL SCIENTIFIC CONFERENCE
26-27 May 2022

ABSTRACTS

Editied by
Iwona Skoczko
Dorota Anna Krawczyk
Ewa Szatyłowicz
Anna Justyna Werner-Juszczuk



Politechnika Białostocka



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Estimation of sulfur dioxide emissions in an automatic boiler with a retort burner in a single-family house for coal and biomass based on the measurement of the heat consumed

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Keywords: *sulfur dioxide, automatic boiler, retort burner, coal, pellet*

The summary should include the following points: The paper presents the estimation of sulfur dioxide emissions as an effect of coal and pellet combustion in an automatic boiler equipped with a retort burner based on the actual heat consumption for heating a building and heating domestic hot water for a single-family house in Poland. In Poland, automatic boilers with an installed retort burner are popular, which can be used to burn various fragmented solid fuels. In Poland, the most popular solid fuel fired in boilers with a retort burner is crushed coal called eco-pea coal. The second fuel used in automatic boilers with a retort planer is biomass in the form of pellets, which is classified as a renewable energy source.

Aim of the research

The aim of the study is to compare sulfur dioxide emissions as a result of combustion of fragmented coal and pellets in an automatic boiler equipped with a retort burner in a typical single-family house in Poland.

Material and methods

Heat consumption was measured over a period of three years during the combustion of eco-pea coal. Based on heat consumption and coal and pellet combustion emission factors in automatic boilers, the average annual emissions of sulfur dioxide for eco-pea coal and pellets were estimated. The presented results of the analysis indicate a significant reduction of sulfur dioxide emissions to the atmosphere by replacing eco-pea coal with fuel made from biomass in the form of pellets.

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Chocolate quality analysis with the application of DSC and texture measurements

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Keywords: *DSC, texture analysis, chocolate, food quality*

The study presents tests of 16 chocolates, including 4 milk chocolates, 9 dark chocolates, and 3 chocolates with additives. Their quality was analyzed with the use of a differential scanning calorimeter (DSC) and a texture analyzer. The DSC tests were provided to investigate the melting characteristics of chocolates, and then the correlation between their thermal and textural properties was examined. Attention was also paid to the frauds used by the producers, including reducing the cocoa content of chocolates or the acid content to reduce production costs. It has been found that the amount of fat and its crystalline state during production influence the rheological, and sensory properties of chocolates and are important in terms of storage stability. Research in a differential scanning calorimeter shows that the cocoa and sugar content affect the melting enthalpy of chocolate. The texture tests showed no correlation between the sugar, fat, cocoa solids content, and hardness and shear work.

Analysis of the state of air pollution with the particulate matter in the town of Supraśl

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Keywords: *air pollution, PM2,5 and PM10*

Summary

Anthropogenic activities cause climate change and therefore weather anomalies. They have occurred in past centuries, but disturbance of the environment, pollution of the atmosphere and destruction of the planet's natural defences, such as the ozone layer, are causing them to become much more frequent and intense. Floods, droughts, the melting of glaciers, the increase in the average temperature of the Earth's surface – all these have been and are being significantly influenced by the hand of human beings. This paper presents an analysis of the most important air pollutants in Supraśl. In order to determine the scale of this phenomenon, air quality tests were carried out according to a specific measurement methodology, i.e. PM2.5 and PM10 dust concentrations were measured using a dust analyser. After comparing the results of individual parameters, they were analysed, discussed and appropriate conclusions were formulated.

Aim of the research

The aim of this study was to analyse the state of air pollution in Supraśl. It was accomplished by measuring the concentrations of suspended particulate matter PM2.5 and PM10 at designated measurement and control points.

Material and methods

The base for the air pollution study in the town of Supraśl was the selection of measurement points. The measurements were carried out between October 2021 and November 2021. The measurements were made with the use of a particulate matter and air quality meter. The device made suction of atmospheric air at the height of approximately 160 cm above the ground. Within thirty seconds it was reading the amount of PM10 and PM2.5 particulate matter.

Derivatives of tannic acid as effective antioxidants

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Keywords: *bioactive substances, tannic acid, spectroscopic methods, biological activity*

There is a growing interest in the use of natural antioxidants as food preservatives, food supplements, drugs or other special purpose materials instead of synthetic antioxidants because of their possible adverse effects including skin allergies, gastrointestinal tract problems or even risk of cancer (Lourenço et al., 2019). Tannic acid is a plant polyphenol that possesses strong antioxidant, antibacterial as well as antiviral properties against Sars-cov-2 virus (Haddad et al., 2022). Moreover, it is a biocompatible and biodegradable chemical. It has been affirmed as a safe food-product additive by the US Food and Drug Administration. It can be extracted from cocoa, green or black tea, pomegranate peel (*Punica granatum*), sorghum, grapes, pears, bananas, black-eyed peas or lentils. Tannic acid is a polyphenolic biomolecule that formally contains 10 galloyl(3,4,5-trihydroxyphenyl) units surrounding a glucose center. The polyphenolic moieties in the structure in tannic acid are responsible for its outstanding biological properties. The presence of catechol or galloyl groups allows the formation of tannic acid-metal complexes (Rahim et al., 2014). The paper reviews the recent knowledge about the antioxidant properties of tannic acid and its application in different industry sectors as new tannic acid – hybrid materials or supramolecular self-assembled molecules. Moreover, the manganese (II) complex of tannic acid was synthesized and studied by means of spectroscopic (FT-IR, UV) and thermogravimetric (TGA/DSC) methods. The antioxidant properties these compounds were established in spectrophotometric DPPH test.

Aim of the research

A review on the antioxidant properties of tannic acid and its bio-applications. Study of the antioxidant properties of manganese (II) complex with tannic acid.

Materials and methods

The manganese (II) complex with tannic acid was synthetized and its composition was studied in the solid state and in the water solution by means of spectroscopic (FT-IR, UV) and thermogravimetric (TGA/DSC) methods. The antioxidant activity of tannic acid and the manganese (II) complex was estimated in DPPH assay.

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Properties of lightweight aggregates for use in construction

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Keywords: *artificial aggregates; PET aggregate; recycling; lightweight concrete; waste management*

Aim of the research

The paper presents the properties of the existing lightweight aggregates and lightweight aggregate made of plastic waste. Properties of aggregates and lightweight concretes were obtained in accordance with the applicable standards. The analysis showed that for structural applications (structures made of concrete on light aggregates) it is possible to use concrete based on ash-pore aggregate due to its high strength and low density. On the other hand, concrete made of Perlit and Penostek aggregates are best suited for insulating layers. In addition, the waste plastic aggregate has many advantages, both in terms of properties as well as environmental aspects.

Material and methods

The properties of aggregates, ie Certyd, Gransil, Perlite, Keramzite, Penostek and aggregates made of plastic waste, were summarized. The bulk density, water absorption, crushing strength and thermal conductivity were compared. The main materials for the production of lightweight aggregates were also presented. For a more detailed analysis, the properties of concretes made on the existing lightweight aggregates, i.e. density and compressive strength, were also compiled.

The bulk density tests were carried out in accordance with the standard (PN-EN 1097-3, 2000). Water absorption and grain density based on the standard (PN-EN 1097-6, 2000). Crushing strength tests of aggregate made of plastic waste were carried out in accordance with the standard (PN-EN 13055, 2016). Whereas the designation of compressive strength according to the standard (PN-EN 12390-3: 2019-7).

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Ecodesing strategies for reducing environmental impact on solar HVAC systems

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Keywords: *LCA, Solar cooling, Evaporative cooling, Environmental impact, Ecodesign*

Aim of the research

Approximately 40% and 36% of total energy consumption and CO_2 emissions, respectively, in the EU are due to buildings (Koroneos and Tsarouhis, 2012). A large percentage of this energy and its associated CO_2 emissions are owing to conventional heating, ventilation, and air conditioning (HVAC) systems (Comino et al., 2020). Solar desiccant cooling (SDEC) systems present high energy saving potential to replace conventional HVAC systems. However, these systems generate a high environmental impact during their manufacturing stage, which may even exceed the benefit in the use phase (Longo et al., 2017)the actual energy and environmental performance of small/medium size installations is not clearly foreseeable. In this paper, an analysis of such systems using adsorption chillers in different European climates is presented. Solar systems have been simulated in TRNSYS and compared to a conventional system employing a vapour compression unit. The results have been used for a Life Cycle Assessment (LCA). Therefore, the aim of this work focused on studying feasible ecodesign strategies for a SDEC system mainly composed of an indirect evaporative cooler, a desiccant wheel and a solar thermal system. More specifically, the considered

strategies were: (a) selection of environmentally friendly materials, such as biocomposites based on natural fibers; (b) weight optimization; and (c) reuse of components at the end of the life phase. The results showed that the proposed modifications for the SDEC system could significantly improve the environmental impact throughout its entire life cycle. Combining all the proposed improvements, a reduction in environmental impact was achieved for all the indicators of between 45% and 60%.

Material and methods

The experimental SDEC system studied was located in Andaltec (Martos, southern Spain) and was designed to supply air conditioned to a research laboratory. The Life Cycle Assessment (LCA) together with Recipe methodology was applied to analyze the influence on the environmental impact of those ecodesign strategies considered. The specific ecodesign modification was the replacement of the aluminum in the structure of the solar collector with steel. Additionally, it was proposed to replace the steel of the desiccant cooling systems structure with a natural fiber-based biocomposite, achieving a 50% reduction in weight. Finally, an improvement of the end-of-life phase was studied in which 50% of components were reused.

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Ecological solutions for the buildings of universities

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Keywords: *ecological construction, energy efficiency, pro-ecological installations*

This work discusses the problem of environmental pollution, which also influenced the activities of public institutions. Actions have been taken to counteract further environmental pollution: solutions to protect the climate and technologies limiting the extraction of natural resources are being implemented. The efforts made are effective, and over the years, a downward trend in emissions of the main air pollutants such as SO_2 and NO_x can be noticed. In order to replace energy sources such as hard coal or lignite, alternative renewable energy sources are being introduced. Green energy sources include wind and sun energy, the energy of the earth's interior, water, or biodegradable raw materials (biomass) such as wood or straw.

The carriers and methods of obtaining energy from renewable sources described in the work are aimed at presenting the positive aspects of the above-mentioned solutions. By using ecological materials, such as lime-hemp composite, the construction industry reduces the emission of greenhouse gases emitted during the production of artificial materials such as sandwich panels or polystyrene used in the construction of buildings. By equipping a building with electricity and heat sources such as photovoltaic panels or a heat pump, energy self-sufficiency can be obtained, moreover, a well-chosen installation can pay for itself in a relatively short period of time and bring profits, so the benefits are not only environmental but and also economical.

Pro-ecological solutions, apart from the environmental aspect, bring economic benefits, and their use contributes to the protection of the environment not only locally, but also globally.

Evaluating buildings green retrofitting to improve urban environment at district level

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Keywords: *sustainable retrofitting, ENVI-met, environmental redevelopment, residential buildings, green urban district*

Aim of the research

The Italian residential building stock is aged and obsolete. This because the 25% of Italian houses was built before 1950. Retrofitting of residential building stock is essential to meet the European aim of carbon-free economy within 2050 as well as the proper outdoor micro-climate comfort. As highlighted in literature the environmental redevelopment of buildings and consequently of the urban context could be obtain for instance greening buildings façades (Lilliana et al., 2020) or applying effective strategies to reduce heat island effect (Riham et al., 2022) (Cortes et al., 2022). The research aims at assessing the influence of implementing both green roofs and façades (as retrofitted measures for existing residential buildings) on micro-climate conditions at both building and urban level. The goal is providing useful indications for the designers to choose the most suitable and possible retrofitted configuration for green urban redevelopment interventions in the context of sustainable cities and community.

Material and methods

The analyses performed focus on the quantification of some environmental parameters such as CO_2 emissions, heat island effect, external temperature, and surface temperature. The research develops starting from outlying a representative urban district area with the definition of an urban grid (80 m X 80 m) located in 3 different Italian cities (Milan, Florence and Palermo). Assuming the district configuration as invariant, different residential building types are considered (tower, multistorey and cour yard) and introduced into the defined urban grid into 2 different configurations (high and low density). These buildings are modelled according to typological features widely spread in the Italian context. The environmental analyses are performed using ENVI-met software considering 3 different conditions. At first, the existing status is evaluated to highlight critical environmental issues, then the introduction of the green roof technology is considered as first redevelopment measure and finally the adoption of green facades is considered. The last intervention addresses only southern oriented external walls with 3 different degrees of greening: 20%, 35% and 50% with respect to the total southern wall surface of each different building type.

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Management of waste from the dairy industry for energy purposes

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Keywords: *dairy sludge, scobs, granulation*

Aim of the research

The aim of our work was an attempt to develop a technology for the management of waste from the dairy industry for energy purposes in the pelleting process through the appropriate selection of material (composition and moisture of the mixture), process and construction parameters. The basis for the created fuel was wood sawdust and dairy sludge.

Materials and methods

The basic raw material used for the research is sawdust from the BSH DĄBROWSCY SP. J.. The added raw material will be post-flotation dairy sludge from the sewage treatment plant at the MLEKOVITA plant in Wysokie Mazowieckie.

The research was divided into two stages. In the first stage, the physicochemical properties of the tested materials were examined: humidity, sawdust sieve analysis, sawdust bulk density. After determining the properties of the raw materials and after granulating, the obtained granulate was tested in terms of: kinetic strength, physical density, and island density, and the heat of combustion and calorific value were examined.

TABLE 1. Methods

Parameter	Methodology
Granulate bulk density	PN- EN ISO 17828:2016-02
The kinetic strength of the granules	PN-EN ISO 17831-1:2016-02
Physical density	Tested using a caliper and an AS 220 / C / 2 laboratory balance by RADWAG
Humidity	PN-76/R-64752
Particle size distribution	PN-89/R-64798

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Catalytic pyrolysis of low density polyethylene

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Keywords: *Silica-alumina catalyst, ZSM-5, acidity, in-situ catalytic pyrolysis, waste plastics*

Aim of the research

Excessive generation of plastic waste and the simultaneous depletion of crude oil (i.e. the of all fossil-based polymers) have been encouraging scientists to improve sustainable methods for plastic waste management. Several thermochemical technologies are addressed to cope with this problem, including pyrolysis, gasification, incineration, etc. (Zhang, 2021). Polyolefins (high density polyethylene, low density polyethylene, and polypropylene) are the most common and dominant types of plastics in the documented amount of plastic waste. Literature reports show that as feedstocks in thermochemical processes, polyolefins are promising to produce gasoline and diesel range hydrocarbons. Being a suitable technology for the conversion of plastics to fuel intermediates, pyrolysis is performed under an oxygen-free environment at moderate to high temperatures (400-600 °C). Thermal (non-catalytic) pyrolysis of polyethylenes generally results in heavier wax (C_{21}-C_{40}) products. To address the production of lighter hydrocarbons from waste plastics, catalytic pyrolysis (CP) is considered to be an effective technique. Due to their high activity in cracking polyolefins and aromatics selectivity, solid acid catalysts (e.g. zeolites, silica-alumina, metal oxides) are mainly utilized in catalytic pyrolysis (Mark, 2020). This research aims to produce silica-alumina catalysts with the sol-gel method and screen/compare their performances with the commercial ZSM-5. By performing the in-situ CP, the target is to produce hydrocarbons in the range of C_5-C_{15}.

Material and methods

In this research, by taking a commercial ZSM-5 (Si/Al = 30) catalyst as a basis, a silica-alumina catalyst (Si/Al = 30) was produced by the sol-gel method. Firstly, alumina and silica solutions were prepared separately. Then, these two solutions were mixed and stirred to obtain a sol. After that, the gelation process is performed. The formed catalyst was dried and calcined. Finally, it was ground and sieved to 60 mesh, 250 μm. The modified catalyst was characterized by NH_3-TPD analysis to examine its acidic properties. Catalysts were heated up to 500°C, and the temperature was kept constant for 30 min. to 1 h. This work is meant to present the preliminary results of semi-continuously operated in-situ catalytic pyrolysis experiments. By in-situ operation of CP, the reactor is charged with the fresh catalysts and plastics simultaneously. Process parameters such as the temperature, plastic type, and catalyst-to-plastic ratio were kept constant when screening the catalysts. To minimize the errors in reporting, the experiments were repeated in duplicates for each catalyst type.

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Treatment of wastewater originated from pesticide industry with photo-Fenton process using Box-Behnken statical design

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Keywords: *raw pesticide wastewater, photo-Fenton process, Box-Behnken design*

Aim of the research

Pesticides are agricultural drugs used to combat weeds, plants and insects that are harmful to the product and affect the efficiency during the cultivation of plants. However, pesticides are highly toxic, carcinogenic and mutagenic in nature, still at low concentrations and pesticides persist in nature for long period. Pesticide manufacturing industry wastewater causes pollution problems due to the toxic components, high chemical oxygen demand (COD), biochemical oxygen demand (BOD), high total dissolved solids (TDS) and intensive color, disgusting odor and generally low pH values (Singare, 2014). Chemical oxidation demand of pesticide wastewater is higher than biological oxidation demand of its, therefore pesticides or wastewater originating from pesticide industry couldn't be easily degraded by microorganisms. Advanced oxidation processes should be preferred as a pretreatment process to treat or degrade pesticides in wastewater and to increase biodegradability of pesticide wastewater before biological treatment methods. The photo-Fenton process as an advanced oxidation process very effective method to degrade pesticides in wastewater and to change form of compounds, to convert easily degraded form for microorganisms in biological

treatment methods (Catalkaya, 2008). The major objective of this study is to investigate the oxidation of raw pesticide wastewaters by photo-Fenton process by using a Box-Behnken statistical experimental design and surface response methodology.

Material and methods

All batch photo-oxidation experiments performed in the completely mixed, batch, cylindrical photochemical reactor contains 16 W low-pressure mercury vapor lamp with a total volume of 2.2 L. In the experiments, the effects of hydrogen peroxide (H_2O_2) and ferrous ion (Fe^{+2}) concentrations and reaction times as independent variables on oxidation of raw pesticide wastewater were evaluated in terms of chemical oxidation demand (COD) removal as dependent variables in Box-Behnken design. Reaction conditions for independent variable; H_2O_2 concentration was 1000-5000 mg/L (X_1), Fe^{+2} concentration was 100-500 mg/L (X_2), reaction time was determined as 5-60 minutes (X_3).

The optimal H_2O_2/ Fe^{+2} / reaction time ratio resulting in the maximum COD (70%) removal was found to be 1000/325/35. After photo-Fenton process as a pretreatment process, treated pesticide wastewater characterization converted to treat with biological treatment method. Therefore, the aim of the research has been succeeding.

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Analysis of heat and smoke release of selected glass/polyester laminates for shipbuilding industry

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Keywords: *glass/polyester laminates, heat release rate, smoke production rate, total smoke production, cone calorimeter*

Glass/polyester laminates offer many advantages over traditional materials for structural applications. They are lightweight, nonmagnetic, corrosion-resistant, highly resistant to shock, dynamic, and high static loads. However, their high flammability and releasing a dense smoke during combustion limitates their use [1].

The application of glass/polyester laminates must be proceded by the measurement of parameters, which are decisive for fire danger. In the shipbuilding industry it is determined according to Fire Test Procedures (FTP) Code by the International Maritime Organization [2].

Cone calorimeter is one of the most important bench-scale instrument for assessing fire hazard of materials. It measures mass loss rate, emissions and HRR at the same time [3]. Results obtained from the cone calorimeter are usually used to characterize, rank and compare fire behavior of materials. The sample is one of the largest used in polymer analysis and of the smallest in fire engineering, thereupon cone calorimeter constitutes an important bond between these sciences [4].

Aim of the research

The glass/polyester laminates used in shipbuilding industry were tested to comprehensively determine their burning behavior.

Material and methods

The glass/polyester laminates were supplied by Łukasiewicz – Industrial Chemistry Institute (Warsaw, Poland).

The cone calorimeter tests were performed in the Main School of Fire Service in Warsaw, using a Fire Testing Technology (FTT) apparatus according to ISO 5660-1:2015 Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement). Horizontally placed samples of size (100 mm x 100 mm x 5 mm) were exposed to a 25 kW/m^2 and a 50 kW/m^2 heat flux with a piloted ignition.

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Water and wastewater management in small tanning facility

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Keywords: *industrial wastewater, tannery, chrome*

Aim of the research

The aim of the study was to present water and sewage management and processes occurring during the technological sequence of natural leather tanning in a tannery plant.

Material and methods

The location of the industry in the leather sector was determined as well as the possibilities of using the products generated in it. The consecutive processes of tanning and wastewater generated as a result were characterized, which are then collected in separate tanks. Changes in the appearance of the skins as a result of the successively occurring processes and the non-uniformity of the post-process baths resulting from the contaminants contained are shown. In 2021, wastewater samples were taken from various stages of production, which made it possible to carry out tests in accordance with current methodologies. This made it possible to determine the pollutants contained in them and that the wastewater generated as a result of the production processes is not biodegradable, except for mixed wastewater, which was characterized as slowly biodegradable. Chromium content averaged 2,20 g/dm^3.

Measurement the parameters of PM2.5 and PM10 of dust suspended in the atmospheric air in the selected areas

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Keywords: dust suspended, atmospheric air, PM2.5. PM10

Outdoor air pollution is a major environmental health problem affecting eve-ryone in low-, middle-, and high-income countries. Ambient (outdoor) air pollution in both cities and rural areas was estimated to cause 4.2 million premature deaths worldwide per year in 2016; this mortality is due to exposure to fine particulate matter of 2.5 microns or less in diameter (PM2.5), which cause cardiovascular and respiratory disease, and cancers. Addressing all risk factors for noncommunicable diseases – including air pollution – is key to protecting public health.

Aim of the research

The goal of this study is measuring the content of dust in the air as parameters of PM2.5 and PM10 and by an air measurement device on the selected air areas and compering the result in an environmental engineering way of look.

Material and methods

Measurements of PM2.5 and PM10 dust were carried out on the campus of the Białystok University of Technology in 20 measurement and control points located throughout

the campus. The results were collected from March to May inclusive. The tests were carried out at a height of 150 cm, using the DT-96 meter. After pressing the START/STOP button, the device measured the concentration of PM2.5 and PM10 dust in the air for 30 seconds, finally displaying the result on the screen in $\mu g/m^3$.

Prioritization of priority pollutants in the scope of the EU Water Framework Directive in Turkey

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Keywords: *water framework; priority pollutants, risk assessment*

The European Water Framework Directive (WFD) is concerned with the long-term management of water resources in Europe. Non-point and point sources of pollution must be taken into account by EU Member and Candidate countries when determining pollutants distinctive to their own nations. Each basin has its own specific pollution profile in terms of agricultural, industrial, and anthropogenic characteristics. Therefore, the measures to be taken within the scope of water management should also be specific to the basin. Likewise, studies should be carried out to match the pollutants originating from the sectors operating in the basin with those sectors. It is important to evaluate the list of special pollutants created due to industrial and agricultural activities within the boundaries of the basin (Çokay, 2016).

Aim of the research

The WFD 2000/60/EC of the European Union establishes the strategic approach for dealing with chemically contaminated rivers. It aims at both the monitoring and detection of 45 priority pollutants and specific pollutants in surface waters. Increasing the number of chemicals to be monitored will prevent the process from being carried out properly. As a result, prioritization studies on river basins gain importance in terms of planning the monitoring of chemicals that require urgent action and reducing monitoring costs. Specific pollutants were determined in the Marmara

Basin and categorized based on prioritization methodology. This enables professionals to determine which pollutants require immediate attention in order to maintain control of the program.

Material and methods

A risk assessment has also been conducted for each individual chemical. In the short-term evaluation, chemicals that require immediate action are included. Medium and long-term plans can be considered for four and eight years, respectively. Besides, pollutants can be categorized according to their detection (category A) and non-detection (category B) at monitoring points or detection in the receiving environment (category C). Another category C is made according to the risk group of the pollutant. If a manufacturing capacity report of the substance has information about the amount of use, the "Combined Monitoring-Based and Modeling-Based Priority Setting" (COMMPS) method can be applied. If this information is not available, elimination is possible using the Total Hazard Score (THS) and Total Impact Score (TIS). If the chemical is in the low-risk group, it is evaluated in the other category D. According to expert analysis, chemicals in these categories can be given more importance.

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Determination of optimal pyrolysis process parameters to maximize gasoline-like renewable fuel production from polypropylene

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Keywords: PP, plastic pyrolysis, process optimization, renewable fuels, plastic waste

Polypropylene (PP) is the most abundant type of plastic in the documented amount of plastic waste and has suitable physicochemical properties for the production of gasoline-like fuels (i.e., C_5-C_{13} hydrocarbons) (PlasticEurope, 2021) through pyrolysis. PP consists mainly of volatiles (about 99.2 wt.%) and trace amounts of ash and moisture ("Phyllis2 – ECN Phyllis classification," 2022). In addition, a high C/H ratio (ca. 6.6) of PP indicates a high calorific value of ca. 47.3 MJ/kg ("Phyllis2 – ECN Phyllis classification," 2022). The amount of energy, which could be generated via the combustion of PP equivalent to 10 wt.% of what is fed to the process, can cover the energy demand of the pyrolysis process (Dispons, 2006). Based on these characteristics, pyrolysis of PP – as an energetically self-sufficient process – can simultaneously provide a renewable fuel and contribute to the reduction of non-recycled waste plastics.

Aim of the research

The intention is to contribute to ISMO 2022 with a critical review of pyrolysis of PP. The report summarizes the status and achievements of research and technology development based on scientific literature, available reports of commercial/industrial trials,

and scientific expertise acquired in our research group in the field of plastic pyrolysis. The objective is to develop some recommendations and suggestions regarding the design of a plastic pyrolysis process on a commercial/industrial scale.

Material and methods

Maximizing the yield and quality of a target product involves optimizing process parameters (e.g., reaction temperature, residence time, etc.) and choosing a suitable reactor that can handle heat transfer limitations. In this work, published research articles focusing on continuous and non-catalytic (NC) pyrolysis of PP are reviewed. The ultimate goal is to find optimal conditions for process parameters and the most suitable reactor type for the production of gasoline-like liquid fuels. Research articles, 14 in total, published between 1984 and 2021, were collected and analyzed in detail. Continuously operated systems are designed to be consistent with industrial processes. At the same time, the other focus is on NC pyrolysis of PP, to find optimal conditions for the production of C_5-C_{13} hydrocarbons without promoters such as catalysts or other upgrades. To understand the relationship between temperature, reactor type, and liquid yield, the maximum allowable pyrolysis temperature, and lowest yield were set to be 550 °C and 70 wt.%, respectively. The data matching the highest liquid production range were further analyzed to determine the residence time of the vapor in different types of reactors was also investigated.

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Bio-applications of metal phenolic networks as functional coatings for drug delivery: a short review

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Keywords: *metal-phenolic networks (MPNs), self-assembly, plant phenolic compounds, drug delivery, nanotechnology*

Phenolic compounds have long been known for use in medicaments, cosmetics, and food additives, due to their valuable biochemical properties, such as antioxidation and metal chelation. However, their low bioavailability and poor water solubility often limit their use in many areas (Zhang, 2014; Dai, 2019). To avoid these problems, new technologies are constantly being developed. One of them, which gained much popularity in recent times, is the creation of metal-phenolic networks (MPNs). MPNs consist of metal ions, such as e.g. Al^{3+}, Mn^{2+}, or Fe^{3+}, coordinated with monomeric building blocks of phenolic ligands containing galloyl and/or catechol groups (e.g. gallic acid, quercetin, or tannic acid). Due to the adhesive nature of PCs, MPNs can be applied as thin bifunctional films on various materials, e.g. polymers, microorganisms, enzymes, mammal cells, etc. The available literature data indicate the promising potential of MPNs films for applications in the biopharmaceutical and medical industries (Eima, 2017; Liu, 2021).

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Test methods for the physical and chemical properties of activated carbon

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Keywords: *activated carbon, physical properties, chemical properties.*

Activated carbon is classified as a porous material, which has been the subject of research and analysis for many years due to its practical application related to heat transfer (insulators), filtration of various media, absorptivity, i.e. the possibility of absorbing/storing gases and vapors, etc. Porous carbon materials used in various fields are characterized by unique physicochemical properties. Activated carbons are materials characterized by a very large specific surface area and a large pore volume.

Aim of the research

The aim of the work was to collect, compile and compare all available techniques and research methods analyzing the physical and chemical properties of activated carbon.

Toxicity assessment of sewage sludge from municipal sewage treatment plants

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Keywords: *Aliivibrio fischeri, toxicity, sewage sludge, municipal sewage treatment plants.*

Aim of the research

The aim of the research was to assess the toxicity of sewage sludge from the municipal sewage treatment plant in Bialystok. Initial and recirculated sewage sludge was analyzed, as well as active sludge from the aeration chamber.

Material and methods

The Microtox system using *Aliivibrio fischeri* bacteria having bioluminescent properties was used in the sewage sludge toxicity tests.

The Microtox kit is used to perform acute and chronic toxicity bioassays as well as to perform mutagenicity tests. *Aliivibrio fischeri* bacteria are a bioindicator showing the inhibition of luminescence under the influence of harmful substances – the light intensity decreases with increasing concentration of toxic substances. All factors disturbing cellular metabolism, as well as significantly affecting the functioning of the enzyme system, reduce the level of bacterial glow, and the decrease in luminescence is determined using the Microtox analyzer.

The strains of *Aliivibrio fischeri* luminescent marine bacteria used in the experiment are highly sensitive to a wide range of toxic substances. They produce visible light

as a result of normal metabolic processes. The change in metabolism under the influence of the tested sample causes a change in the intensity of the emitted light, which is directly proportional to the biological activity of the sample.

In the course of this study, an analysis of the toxicity of preliminary and recirculated sewage sludge and activated sludge from the municipal sewage treatment plant in Bialystok was performed. The test results are presented as EC50, the sample concentration that reduces the amount of light produced by 50%. Then, in order to determine the toxicity of the tested sewage sludge, the EC50 results were converted into TU units (toxic units), which, according to the Persoone system, allow the tested sewage sludge to be classified into one of 5 toxicity classes, where: class 0 means a non-toxic sample, and class 4 – very highly toxic sample.

Optimization of selected parameters of the elements of a single-family house with estimation of their contribution to energy saving

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Keywords: *annual energy demand for heating / cooling, single-family building, architectural and spatial parameters, solutions of structural elements, physical parameters of windows, deterministic mathematical model, optimization*

Aim of the research

The aim of this study is to analyze the impact of selected design parameters on the energy demand for heating $Q_{H;nd}$, cooling $Q_{C;nd}$ as well as heating and cooling $Q_{H/C;nd}$ of a traditional single-family building in the climatic conditions of Bialystok and optimization of these parameters. The parameters selected for the analysis were divided into 3 groups. The first group includes architectural and spatial parameters concerning the dimensions of rooms and windows: the height of the rooms h and the window area change coefficient k. The second group is a group of construction parameters in which the following solutions of building elements were considered: material density of the internal layer of external walls ρ_1, material density of internal walls ρ_2 and thickness of internal walls d. The third group is a group of physical parameters, where the following window parameters were considered: the heat transfer coefficient of the glazing U_g and the total energy transmittance of solar radiation of the glazing g_{gl}.

The research results showed that the factors from the first group played the most important role in saving energy (their contribution amounted to 1,802.90 kWh/a,

i.e., –56.0% of the total value of energy saving), slightly smaller – factors from the third group (their share amounted to 1435.59 kWh/a, i.e., –44.6%), and the lower – factors from the second group (their contribution was only 246.99 kWh/a i.e., –7.6%). The values of individual parameters were also determined, ensuring the minimum and maximum of the function $Q_{H/C;nd}$.

Material and methods

The annual energy demand for heating and cooling was simulated in DesignBuilder, based on the powerful EnergyPlus computing engine. Mathematical modeling was used as the research method. A 7-factor computational experiment was carried out according to the second-degree design. When selecting the values of the analyzed input factors, the properties of typical solutions used in single-family buildings in Polish conditions were based on a symmetrical three-level plan. The developed three models of output functions were used to analyze the influence of factors, and the optimization of the parameters according to the energy criterion, using the iterative (numerical) adequate area search method, allowed to determine the contribution of each of the three groups of parameters to energy saving.

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The role of nanomaterials in wastewater treatment

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Keywords: *adsorption, heavy metals, nanomaterials, water treatment, biosorption*

Aim of the research

The aim of this review was to bring together the recent data on nanoparticles used in heavy metal removal and the possibility of their use as biosorbent nanocomposites. Treatment of water and wastewater contaminated with heavy metal ions is one of the main tasks of environmental engineering. This is due to the increasing industrialization of society. In addition, heavy metals getting into the environment result in serious disturbances in the metabolism of fauna and flora. One of the sustainable approaches proposed by science is the use of low-harmful biosorbents, produced on the basis of waste from the agri-food industry, including fruit pomace. Due to the relatively low specificity and, consequently, insufficient sorption efficiency, attempts are made to modify such wastes, which will still be economically viable (Chand & Pakade 2013).

Adsorption is one of the most described method used to remove the non-biodegradable pollution such as heavy metals, dyes, drugs. During the last decade, nanoadsorbents were noted to be the promising solution in heavy metal removal in water and wastewater treatment (Thekkudan et al 2017). Among many nanoadsorbents, some materials stand out, for example MgO, ZnO or hydroxyapatite nanoparticles (Dhiman & Kondal 2021, Chand & Pakade 2013). According to the literature data, they have low toxicity and are easily accessible sorbents. It was already proven that some nanoparticles linked with biomass show fast adsorption rate and good sorption efficiency

towards a broad range of heavy metal ions in wastewater. Their application in water treatment results in significantly improved performance due to bigger surface area, stability in operating conditions and no secondary pollution (El-Nagar et al 2020). The use of advanced nanoengineering technologies, such as an innovative combination of the basics of chemical engineering and nanotechnology, expands the horizons on the treatment of waters contaminated with heavy metals (Dutta & Charingia 2020).

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Study of antioxidant properties of zinc and manganese complexes with phenolic acids

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Keywords: *antioxidants, phenolic acids, superoxide dismutase, IR spectroscopy, Raman spectroscopy*

Superoxide dismutase the strongest antioxidant found in cells. It is an enzyme that is a part of antioxidant defense system developed by organisms to protect themselves from hazardous activity of free radicals (Ighodaro & Akinloye, 2017). These atoms or molecules both naturally occur in the body and may be formed as a result of external factors. In addition to a number of important functions they perform, their excess can contribute to the formation of many disorders in the normal functioning of the body (Phaniendra et al., 2014). Unfortunately, due to its relatively large size, superoxide dismutase cannot be used to treat mentioned disorders, so for years the search for compounds with similar activity has been continued (Wozniak & Czyz, 2008). One group of the compounds known for their antiradical properties are phenolic acids. They have both the ability to scavenge free radicals by donating a hydrogen atom and exhibit indirect antioxidant activity (Sevgi et al., 2015). Their properties point to their potential use as SOD mimetics, low molecular weight compounds that act similarly to superoxide dismutase. In many of the SOD mimetics known to date, there is a metal ion that is the acceptor of the unpaired electron from the free radical, thereby inactivating it (Wozniak & Czyz, 2008).

Aim of the research: Synthesis of zinc and manganese metal complexes with p-coumaric, cinnamic and caffeic acids and study of their antioxidant properties.

Material and methods: Spectroscopic studies, i.e. IR and Raman spectroscopy, were carried out. The antioxidant properties of the complexes were determined by studying the inhibition of OH radical and SOD activity. Theoretical values of HOMO and LUMO molecular orbitals for the studied complexes were also determined as a parameter of their antioxidant capacity.

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Growth of plant biomass in the presence of washings from swimming pool facilities: selected indicators in the context of the possibility of wastewater recycling

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Keywords: *circular economy, ecotoxicology, swimming pool, water recovery, wastewater recycling*

Aim of the research

One of the possibilities of using the recovered water from wastewater is irrigation of greenery in urban/recreational, or sports areas during periods of drought or insufficient rainfall. This would reduce the consumption of tap water, which should not be used for such purposes in the face of dwindling water resources. The research aimed to conduct an extended analysis of the quality of the washing: physicochemical and ecotoxicological. To assess the recycling potential of swimming pool wastewater, diluted in water matrices (deionized water, tap water, rainwater) were used, with the volume fraction of the washings ranging from 5 to 100%.

Material and methods

The washings were collected in two municipal swimming pools once a week, with five independent samples for each circulation. As part of the physicochemical analysis, among others, the pH, specific conductivity (EC), redox potential, ultraviolet

absorbance UV254, total suspended solids (TSS), free and total chlorine, total nitrogen, ammonium nitrogen, total phosphorus, cyanuric acid, phenol index, aluminum, zinc, and Chemical Oxygen Demand (COD), total organic carbon (TOC), total carbon (TC) and dissolved organic carbon (DOC). The ecotoxicological assessment was based on growth inhibition tests of selected plant organisms – *Lemna minor*, *Sinapis alba*, *Lepidium sativum*, and washings in selected water matrices.

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Agricultural biogas plant – an important element of the circular economy

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Keywords: *biogas, organic waste, fermentation, Combined Heat and Power, digestate*

Circular economy is an economic concept in which products, materials and raw materials should remain in the economy as long as possible, and the generation of waste should be minimized as much as possible. In this context, supporting the transformation towards circular economy is an indispensable element of creating a low-emission, resource-efficient, innovative and competitive Polish economy.

The circular economy roadmap, which is one of the strategic projects of the Responsible Development Strategy, which is based on the commonly used circular economy model in the EU (developed by the Ellen MacArthur Foundation), assuming the existence of two cycles: technical (including non-renewable resources) and biological (including renewable resources), in which the biogas sector fits perfectly. In 2021, biogas installations used more than 4.3 million tonnes of waste for production, which is the same as their disposal. Estimates of domestic units indicate that Poland has approximately 120 – 150 million tonnes of useful biogas waste. The potential for biogas production from waste is around 13-15 billion m3 of biogas per year. Biogas plants fit perfectly into the model of highly efficient ecological business, in which waste is the raw material for the production of biogas and digestate, all within the framework of a circular economy. The biogas generated in the methane fermentation process can be used as a fuel to power an internal combustion engine that produces electricity and heat in combination, or it can be treated to biomethane and then injected

into the gas network or liquefied to bioLNG or compressed to bioCNG. The by-product of the methane fermentation process is the production of digestate, which is an excellent organic fertilizer.

The growing importance of biogas and biomethane was emphasized in the Directive of the European Parliament and of the Council (EU) 2018/2001 of December 11, 2018 on the promotion of the use of energy from renewable sources (the so-called RED II). The RED II directive is currently the basic legal act regulating the renewable energy market in the European Union. The overarching goal of the RED II Directive is to achieve the EU target of increasing the share of renewable energy in the EU's energy mix to at least 32% by 2030.

Moreover, biogas and biomethane, due to the high reduction of GHG emissions, reaching even 190%, may play an important role in the process of decarbonisation of transport.

Aim of the research: determining whether it is possible to develop the biogas sector to such an extent as to use its full potential to utilize organic waste generated in Poland, at the same time obtaining the possibility of supplementing gaseous fuels with biomethane, which in 2030 should have a 10% share in gaseous fuels transported through gas networks.

Material and methods: analysis of legislation and formulas to support the biogas sector.

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Comparison of MTT and Cell-TiterGlo tests applied for cytotoxicity evaluation of compounds from the group of polyphenols

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Keywords: *MTT, Cell-TiterGlo, ATP, Caco-2 , cynarin*

Aim of the research

The aim of this study was to compare the utility of the colorimetric MTT assay and the bioluminescent CellTiter-Glo assay for the evaluation of compounds from the polyphenol's group. Analysis of both methods was performed by comparing the obtained results of the viability of Caco-2 cells treated with a wide range of concentrations of 4 polyphenolic compounds: chicoric acid, caftaric acid, caffeic acid and cynarin. The results show some discrepancies in the cell survival assay. Moreover, the overestimation of Caco-2 cell viability using MTT assay confirms the occurrence of interference between MTT assay and analyzed polyphenols. Based on the conclusions drawn, it was confirmed that the CellTiterGlo assay has a higher accuracy of measurement, thus providing more reliable results of cytotoxic analysis of polyphenols, compared to the MTT assay.

Material and methods

Cytotoxicity assays are a fundamental tool used in molecular biology, as well as in pharmacy, for drug discovery studies. Most of these assays are based on the measurement

of cell viability and proliferation. The reduction of MTT (3-(4,5-dimethylthiazol-2-yl) -2,5-diphenyltetrazolium bromide) is a widely used colorimetric assay method to determine the viability of cells/cytotoxicity. In recent years, there has been a growing interest in polyphenolic compounds, which exhibit many health-promoting properties and therefore carry enormous therapeutic potential that could be used in the fight against various diseases of civilization (i.e.: cancer, atherosclerosis, obesity, diabetes). Commonly used MTT test may provide incorrect results due to the phenomenon of chemical interaction with plant extracts. More and more assays based on the measurement of intracellular ATP (i.e. CellTiter-Glo) are appearing on the market, which according to many scientists are a promising alternative to the tetrazolium salt reduction test.

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Heat pump market in Poland in 2020-2021

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Keywords: *heat pumps, renewable energy sources, heating, cooling, heat pump market*

Aim of the research

The aim of the research is to show the trends in the heat pump market in Poland in recent years and discuss the factors shaping this market. The analysis is also to determine what actions should be taken to overcome the barriers that hinder the development of the heat pump market in Central and Eastern Europe (CEE) countries, on the example of Poland.

Material and methods

To conduct the analysis, a detailed review of reports, data and papers on the heat pump market in Poland in 2020-2021 was performed. Using Polish Organization of Heat Pump Technology Development reports (PORT PC, 2022) the number of units sold in each year was determined and the results were compared to the achievements of other European countries. The study also described two scenarios (baseline and optimistic) for the growth of the heat pump market to 2030. Based on the data contained in (Fodrowska, 2022), the factors shaping the heat pump market, including European and national policies and financial support programs, were presented and discussed, and with reference to the report (Crowdway, 2021) the barriers impeding the dynamic development of heat pump technology were identified.

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Antioxidant studies of rosmarinic acid and its complexes with zinc and copper in experimental and theoretical approach

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Keywords: *rosmarinic acid, FRAP, DPPH, DFT studies, metal complexation*

Aim of the research

Rosmarinic acid consist of 3,4-dihydroxylphenyllactic and caffeic acid molecules linked by an ester bond. It occurs in in species of the Boraginaceae and the subfamily Nepetoideae of the Lamiaceae and in other higher plant families. Rosmarinic acid plays an important role in plant cells as a defense compound against herbivores and pathogens [1]. In human body, rosmarinic acid and its derivatives exhibit biological activities – they improve the cognitive performance, prevent the development of Alzheimer's disease, show cardioprotective effect and are applied in cancer chemoprevention [2]. High antioxidant activity of rosmarinic acid contributes to the strong antitumor properties. Studies performed on rats proved that rosmarinic acid at the concentration of 5mg/kg body weight reduce lipid peroxidation. Anticancer activity is also a result of its ability to increase the apoptotic proteins expression [3]. In the body of rat, rosmarinic acid is metabolized to coumaric and caffeic acid. These metabolites have a great impact on reducing the cholesterol concentrations in rats cells by increasing fatty acid **β**-oxidation activity [4]. The aim of the research is study the influence of complexation of rosmarinic acid with zinc and copper on its electronic structure antioxidant activity by means of computational studies and experimental methods.

Material and methods

Zinc and copper rosmarinates were obtained in two step reaction. The first step consist in obtaining the sodium salt of rosmarinic acid, by adding in stechiometric ratio (1:1) the powder of rosmarinic acid to the sodium hydroxide water solution (0,1M). Obtained suspention was placed in ultrasonic bath and heated up to 60°C until the complete dissolvatation of rosmarinic acid. In the second step, the water solution of zinc and copper chloride were added in order to obtain zin and copper rosmarinates respectively. The chloride salts were added to the sodium rosmarinate solution in molar ratio like 1:2 (2,5 ml of 0,1M zinc/copper chloride). The complexes were placed in shaker for two hours at room temperature. Precipitate were washed with acetone to rinse the remaining chlorides under the control of $AgNO_3$ solution. Obtained solution were dried in 70°C. The compounds obtained this way were subjected to spectroscopic and antioxidant test. The FRAP and DPPH antioxidant assays were performed with initial concentration of rosmarinic acids and its complexes of $5 \cdot 10^{-5}$M of water solutions. Theoretical studies were performed using the Gauss 08 computational program. All theoretical calculations were made in the B3LYP database using the LAN2DLZ density functional.

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Analysis of the potential of effective microorganisms in plant production

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Keywords: *Effective Microorganisms, agriculture, environment, plants*

Aim of the research

The aim of this study was to present the possibility of using Effective Microorganisms as an ecological alternative to conventional crop production systems.

Material and methods

The study used plant and soil material from the pot experiment in the form of soil before sowing as well as plants and soil after 2 weeks of the experiment. The content of micro and macro elements in plants and four different types of soil available in the garden shop were determined (universal substrate of the highest quality, universal soil, gardening substrate for sowing and quilting and substrate with acid peat). 4 soils and 2 plants were selected, which were marked in the further part of the work in various combinations of G1 – G20 and R1 – R14. The soil pH varied from 3.5 to 6.8. They came from the orno-humus level (0-20 cm).

Two plants were selected for research on the potential of Effective Microorganisms: one from the monocotyledonous class, which is wheat (*Triticum aestivum L.)* and one from the dicotyledon class, which is rape (*Brassica napus L.)*. The choice of plants was determined by their belonging to different systematic classes. The company Greenland Technologia EM Sp. z o.o. is the exclusive licensee

of EMRO Japan for Poland and Central and Eastern Europe and is responsible for the production and sale of products based on the original Japanese EM technology. The preparation EM Naturally Active was registered as an organic fertilizer by the decision of the Minister of Agriculture and Rural Development, Study No. 281/11 of March 31, 2011.

The pot test was carried out at the Department of Environmental Technology, Bialystok University of Technology in 2021. The test was carried out in plastic containers with a volume of 150 ml (upper diameter 80 mm), 100 g of air-dry soil was placed and then moistened to 55% of full water capacity. When the soil was already moist, wheat and rape seeds were sown in the amount of 10 seeds per one container. Previous evaluation showed a germination capacity of the test plants' seeds of >95%. The tests were carried out in laboratory conditions, at room temperature (20-22°C) with natural lighting lasting 12-16 hours/day. The humidity level was checked daily by checking the weight of a number of selected containers of each combination. The grain of wheat and rape in the test samples was watered with a 1% solution of Naturally Active EM, and the control samples with distilled water. The experiment was carried out for fourteen days.

The content of micro and macro elements was determined using the method of atomic absorption spectrometry (ASA). This analytical technique allowed for the determination of chemical elements such as: B, Al, P, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Cd, La, Pb, K, Ca, Na, Mg in samples.

Environmental and water-use efficiency for indirect evaporative coolers in Southern Europe

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Keywords: *evaporative cooling technology, experimental tests, air-cooling, water-use efficiency, CO_2 emissions*

According to several studies in the last decade, Heating, Ventilating and Air Conditioning, HVAC, systems consumed about 20% of energy consumption in buildings (Mohammed, 2022). Evaporative cooling technology presents an interesting solution to conventional cooling technologies based on vapor compression systems. There are two main types of evaporative cooling systems: direct evaporative cooler, DEC, and indirect evaporative cooler, IEC. Most of the experimental studies of IEC systems focused on the analysis of energy performance. However, few research works have analysed water-related indexes in this type of air-cooling system. A methodology to determine the water-use efficiency in evaporative coolers was developed (Sahai, 2012). Another work showed high values of water-use efficiency for the IEC technology and combined systems with indirect evaporative coolers (Pistochini, 2011).

Aim of the research

Based on the lack of research studies on water indexes of IECs, in the present work the environmental and water-use efficiency for indirect evaporative coolers in Southern Europe is presented.

Material and methods

Cooling capacity, $\dot{Q}_{cooling}$, energy consumption, $\dot{W}_{cons}$, and water consumed, $\dot{M}_{W}$, of an IEC system were experimentally evaluated under different working parameters and climatic conditions. The annual values of these indexes, CO_2 emissions, E_{CO2}, and the Seasonal Energy Efficiency Ratio, SEER, were obtained for different climatic zones according to the developed mathematical models. The environmental impact in different Southern European countries was compared using the following indexes: cooling capacity per unit of water consumed, $\dot{Q}_{C\text{-}W}$, cooling capacity per CO_2 emission, $\dot{Q}_{C\text{-}CO2}$, and water consumption per CO_2 emission, $\dot{M}_{W\text{-}CO2}$.

This IEC system worked with a single inlet air stream, IA, which was divided into two air streams: exhaust air, EA, and outlet air, OA. Several experimental tests were carried out under different steady-state air conditions – inlet air temperature, T_{IA}, inlet air humidity ratio, ω_{IA}, inlet volumetric air flow, $\dot{V}_{IA}$, and the exhaust ratio, R_{EX} – to develop the IEC models of $\dot{Q}_{cooling}$, $\dot{W}_{cons}$ and $\dot{M}_{W}$. Another part of energy simulation, using the TRNSYS tool, was carried out to compare the environmental impact in different climatic zones in Southern Europe.

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Operating costs of air and ground source heat pumps

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Keywords: *operating cost, seasonal coefficient of performance, upper source, brine-to-water heat pump, air-to-water heat pump*

Aim of the research

The development of renewable energy is essential to the achievement of fundamental energy policy objectives. These actions were discussed at the COP26 summit in Glasgow, which accelerated actions related to the Paris Agreement, as well as the United Nations Framework Convention on Climate Change. Poland is one of the member states that have committed themselves to support measures that neutralize carbon dioxide emissions and support the renewable energy market. Promoting the use of alternative energy sources allows greater diversification of supply sources and creates conditions for the development of dispersed energy generation based on locally available resources. Local resources such as water, air, and ground heat can be used by residential buildings through the use of heat pumps as heat sources.

The operating cost of a heat pump is related to the temperature of the upper and lower sources; heat pump type, operation mode and the electricity billing tariff.

This study aims to determine how the variable operating parameters affects the efficiency and operating costs of the heat pump during the annual operating period.

Material and methods

A heat pump efficiency calculation was carried out for a single-family house located in climate zone IV in Białystok. The analysis was carried out for a brine-to-water ground pump and an air-to-water pump. A monovalent mode for the ground pump and a mono-energy mode for the air source heat pump were assumed. Three bivalent temperature values were assumed for the air pump: –10, –9 and –8°C. Electricity consumption calculations were carried out for five values of the upper source temperature: 35, 40, 45, 50 and 55°C, taking into account its variation with respect to the outdoor air temperature. The calculations were carried out for outdoor air temperature determined for each hour of the statistical year, considering the variation of thermal output and electricity consumption. The SCOP values were calculated. Electricity consumption and its cost were determined according to three tariffs offered by PGE: G11, G12 and G12w.

The operating costs of heat pumps depend on the type of pump (air or ground) and on the operating parameters of the heating system: the temperature of the heating medium in the central heating system and the assumed bivalent temperature. The lowest operating costs are ensured with a ground source heat pump. With an air source heat pump operating in mono-energy mode, it is important to set the bivalent temperature at which the second heat source is switched on: the lower the temperature, the lower the operating costs. The most favorable electricity tariff is the weekend tariff G12w. For the heating of the building, the 24-hour tariff G11 with identical charges during the day and night is not recommended.

Investigation of thermal bridges of a new high-performance windows installation using 2-D and 3-D methodology

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Keywords: *thermal bridges, thermal conductivity, thermal insulation, window, passive house*

Aim of the research

This work focuses on the investigation of thermal bridges of a new high-performance windows installation. The main aims is to investigate in detail the thermal properties of the window installed in the thermal insulation layer and to compare different installation methods and thermal bridge evaluation methodologies from the point of view of thermal physics.

Material and methods

The investigation of buildings elements regarding energy saving is the paramount issue at this moment when the EU Directive drives the goals to achieve which focuses on the energy performance of buildings and energy efficiency (Fokaides at al., 2020).

The correct window installation is still one of the most difficult hurdles that must be overcome in order to achieve a higher buildings' energy efficiency (Bergero at al., 2017).

Under this study two cases of window frame installation in stone wool boards were analyzed.

In order to evaluate the influence of fasteners on heat loss through the window opening edge, the computer program HEAT3 with a 3-D temperature field calculation was used.

Conclusions

The results show, that comparing the obtained values of the thermal bridge according to 2-D and 3-D calculation methods, the values show a difference of 68 %.

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Calibration of the hydraulic model based on hydrant tests

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Keywords: *model calibration, hydrant field test, water distribution system, water supply, fire flow test*

Water companies are investing funds in the preparation of hydraulic models of the Water Distribution Systems (WDS). Hydraulic models should be calibrated. The calibration process consists in improving the computer model (CM) by adjusting its parameters and simulated values to the values measured during the actual operation of the WDS (Walski et all, 2003).

Field tests can include measurements of flow, pressure, head, water level, status of devices (open/closed valves, on/off pumps etc.). One way to prepare the best possible data set is to perform hydrant tests (Grayman et all, 2006). The obtained results enable an accurate mapping of the actual WDS operation in a CM. A correctly made CM can be used to perform reliable simulations of various situations, optimize the work of the WDS, detect leakages, plan the expansion and modernization of the WDS etc. (Świętochowski, 2020).

Aim of the research

The aim of the article was to check the possibility of using a CM calibrated in relation to flow and pressure and calibrated with the use of hydrant tests to analyze the fire protection of the WDS in areas not covered by field measurements.

Material and methods

The research was carried out on an actual branched WDS of varying heights. A computer model was made in the EPANET software, where you can analyze static and dynamic models and calibration results (Rossman, 2000). Hydrant tests were performed using the HYDRO-TEST kit (static and dynamic pressure and hydrant flow) (Biatech, 2020) and pressure data loggers.

As a result of the field tests and the performed analyzes and computer simulations, a high correlation was obtained between the measured and simulated values, and between the static pressure values and the obtained dynamic pressure. The model of the tested network, prepared and calibrated on the basis of fire mains tests, can be used to simulate various variants of the network operation, ensuring a high probability of obtaining computer-simulated values during the implementation of solutions in the field.

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Application of multi-criteria analysis in the EIA

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Keywords: *EIA, MCDA, TOPSIS, AHP, sustainable development*

Aim of the research

Environmental Impact Assessment (EIA) is an instrument of sustainable development, because it creates methodical and procedural basics to assess creates methodological and procedural foundations for including environmental protection issues in the development planning process. EIA allows predicting and thus avoid, minimize, mitigate or (as a last resort) compensate for significant negative environmental impacts, it creates conditions for preserving the value (also social and economic) and productivity of ecosystems and maintaining the functions they perform.

There are many methods of assessing the environmental impact of an investment. Each of them is helpful in determining the most favorable decision variant, it needs to be adjusted to the decision problem. Multi-criteria decision methods (MCDM/MCDA) in the EIA are widely used as they are universally applicable, they can be adapted to many decision problems. MCDA methods have only three steps, which consists of definition of criteria and options, selected variants and criteria and processing these values and ranking the alternatives (Triantaphyllou, 2000).

The paper focuses on selection between technological variants of an investment in the Environmental Impact Assessment as a base material, using a different method than the original. The author will select the optimal technological variant using the MCDA methods with hybrid approach, combining the AHP method to determine the variant weights, as well as the TOPSIS methods to create the variant ranking. The results will be compared.

Material and methods

The analysis starts with the selection of decision variants that will be analyzed. The next step is the appropriate selection of criteria so that they provide a lot of information for the analysis, are unique and constitute a good representation of the criteria from their group. The criteria should be ranked by assigning weights to them, and then defined as stimulants (having the nature of benefits) and destimulants (having the nature of costs) (Kobryń, 2014).

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Investigation of the effect of waste polypropylene (PP) originated metal contaminants on the pyrolysis of PP

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Keywords: *Chemical recycling, pyrolysis, plastic waste, polypropylene, ICP-MS.*

Aim of the research

Municipal solid waste generation is increasing due to the growing population and industrialization. Plastic waste constitutes the high partition of municipal solid waste. Plastics are among the most used materials having miscellaneous utilization areas ranging from food packaging to the automotive sector. Pyrolysis is a suitable technology concerning the recovery of energy and fuels from plastic waste, given that the plastics are petroleum-based, and can be considered as feedstocks for the production of liquid hydrocarbons with high calorific values. The elemental composition, volatile matter and ash contents of individual plastic types affect the conversion yield and the quality of the liquid product. While conventional fossil-based diesel has a calorific value of 43 MJ/kg according to the ASTM 1979 standard, the calorific values of oils produced from polyolefins (i.e. HDPE, LDPE, and PP) by pyrolysis are higher than 40 MJ/kg (Kumagai et al., 2020).

Various types of metals such as calcium, aluminium, copper, zinc, iron, etc., may be present in plastic waste due to numerous additives used in plastic production as fillers, photo-stabilizers, flame retardants, lubricants, etc. (Kusenberg et al., 2022).

It is important to investigate the effects of these metal contaminants during the pyrolysis of polypropylene. Hence, this research aims to characterize the PP waste collected in Izmir, Turkey, and evaluate the catalytic effects of the presence of ash during the pyrolysis of PP in semi-batch processing mode.

Material and methods

For this research, a total of 78 kg of household plastic waste (HPW) originated in Izmir, Turkey, was collected and classified according to Resin Identification Codes (RIC) as defined by the ASTM D7611. Polypropylene (PP) had the highest share among the polyolefins, with 27.6 wt.% in collected HPW. PP's physicochemical properties were determined using various characterization techniques, such as proximate (ASTM D3173, ASTM D3174, and ASTM D3175) and ultimate analysis (for the determination of CHN/S), Thermogravimetric Analysis (TGA), and Differential Scanning Calorimetry (DSC). The individual quantities of metals in the PP originated ash was investigated by an Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Scanning Electron Microscopy – Energy Dispersive X-Ray Spectroscopy (SEM-EDX).

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Air pollution analysis from industrial processes in Poland

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Keywords: *air pollution, industry, industrial processes, Poland*

Air pollution of anthropogenic origin is a characteristic element of the urban environment. Their main sources are fossil fuel combustion processes for municipal, transport, and industrial needs, as well as production processes that release specific pollutants into the atmosphere, characteristic of a given type of production. The second type of anthropogenic pollution, i.e. the emission of pollutants into the atmos-phere from industrial processes, according to the SNAP system (Selected Nomenclature for sources of Air Pollution) is one of the 11 categories of pollutant emissions to the at-mosphere. Emissions from industrial processes were assigned the code SNAP04, and combustion processes in the industry were assigned the code SNAP03. Both of these categories include industrial emissions.

Aim of the research

Therefore, it was decided to compare emissions from industry to emissions from other sectors according to the SNAP classification. This paper presents the emissions of pollutants covered by the emission limits set out in Directive 2001/81/EC7 and Directive 2016/2284, i.e.: SO_2, NO_x, NMVOC, NH3, PM2.5, PM10, and TSP for all emission categories according to SNAP. Emissions from industry are presented against the background of emissions from other classification categories.

Material and methods

The data was compiled on the basis of the Report of the National Center for Balancing and Management of Emissions

Test bench for complete characterization of evaporative cooling pads

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Keywords: *Experimental facility, direct evaporative cooling, pad thickness, pad material, water distribution system*

Aim of the research

Nowadays we can found many studies about evaporative cooling pads, but it does not exist a uniform methodology for the experimental tests and many factors are less studied (Tejero-González & Franco-Salas, 2021). The goal is to design and build a versatile experimental facility that enables the characterization of the pads under different operating conditions: Airflow (velocity), relative humidity, temperature, pads thickness, pads material and water distribution system. The test bench will permit the use of three types for water distributors, any type of pads material, and with three different thickness.

Material and methods

The present work briefly reviews the existin8g literature and analyses the main influence factors and the key operating parameters. Once identified, a test bench is designed and conceived to implement any type of evaporative cooling pad in terms of material and geometrical characteristics, as well as different water distribution systems. An Air Handling Unit is used to reproduce the desired air velocity, dry bulb temperature, and relative humidity, enabling the performance of the tests under controlled

conditions. Measuring equipment is selected to register the variables needed for the calculation of the target operating parameters: pressure drop, saturation effectiveness, and cooling capacity, among others (Seifi et al, 2019)

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Comparison of global water consumption in adiabatic and air-cooled condensers

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Keywords: *adiabatic condensers, air-cooled condensers, chillers, energy efficiency, energy mix, water consumption*

Aim of the research

The main objective of this work is to check the suitability of different refrigeration systems according to their condenser type in diverse climate zones around the European continent, all of it in terms of water consumption and energy efficiency.

Material and methods

In this paper it is intended to demonstrate a simple hypothesis: the use of adiabatic condensers versus air-cooled condensers may result in global water savings of chillers in certain climatic zones. With this aim, it is first necessary to have the information about different overall electricity mix in the target countries, with which it has been estimated the water consumption associated to electricity generation. Then, the chiller Energy Efficiency Ratio is related to the condensing temperature, which enables the estimation of the electric energy consumption in terms of the climate conditions. The actual global water consumption is finally related with both the direct water use and the water derived from the generation of the electricity consumed.

Eventually, the present document sets out the key findings of the study, with calculated results about global water consumption associated to adiabatic condensers and air-cooled chillers depending on climate zone and electricity mix.

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Application of the chemical leaching method for the recovery of Li and Co contained in spent Li-ion batteries

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Keywords: *Li-ion batteries, leaching, recovery of metals, waste management, environmental engineering*

Aim of the research

Waste batteries and accumulators are a source of many raw materials, including metals necessary for the production of various electrical and electronic equipment. Currently, the most popular type of batteries used in small-size electronic devices, but also in hybrid and electric vehicles, are lithium-ion batteries (Li-ion; LiBs) in which lithium and cobalt are included. These elements are also considered as critical raw materials because they are indispensable components of the most modern technologies used all over the world, and thus their natural resources are overexploited. As a result, such action may lead to their rapid depletion, and the production of new products containing lithium and cobalt will be at risk. The solution to this problem is the use of secondary metallic materials contained in polymetallic waste, an example of which are spent Li-ion batteries. In industrial and laboratory practice, various techniques are used to recover metals contained in waste LiBs, including hydrometallurgical methods involving the leaching of elements from the battery powder into solution. Thanks

to the use of appropriate process parameters, i.e. the concentration and type of leaching and reducing agents, the ratio of solid to liquid phase, temperature and duration of experiments, it is possible to achieve high, even 100% rates of metal recovery, including Li and Co.

Taking into account the increased demand for the recovery of critical metallic raw materials (Li and Co) included in the waste Li-ion batteries, the concept of laboratory experiments in the this field was developed.

Material and methods

The research material was anode-cathode battery powder obtained as a result of manual dismantling and fragmentation of spent Li-ion batteries contained in laptops of various brands. For the separation of metals – lithium and cobalt, the acidic reductive leaching method was applied. The conducted leaching experiments were performed in the presence of organic and/or inorganic leaching and reducing agents. The achieved results of research confirm the possibility of using chemical leaching for the recovery of the tested metals, which may significantly contribute to the reduction of the uptake of metallic raw materials from their natural resources.

Air monitoring system based on unmanned aerial vehicle powered from the ground

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Keywords: *unmanned aerial vehicle, tethered drone, air monitoring system, air pollution, air quality*

Recently, one can observe a rapid development of various types of unmanned aerial vehicles (UAVs) applications in areas related to environmental protection (Gu Q., Jia Ch. 2019, Yao et al. 2018). The first example is the use of UAVs for observation and monitoring using vision systems equipped with heads for daytime, infrared thermal and hyperspectral observations. These enable, among other things, the early detection of fires, smoke outbreaks, plant disease conditions based on the analysis of the electromagnetic radiation they reflect. Another application is the detection of pollutants that are products of illegal waste incineration.

Aim of the research

Aim and scope of this paper was to design prototype and experimental verification of air quality indicator, which was a module of the MISIO system, the unmanned aerial vehicle platform that is result of R&D project POIR.01.02.00-00-0072/16 titled "Modular surveying-inspecting system based on a flying multirotor platform powered from a ground station" co-financed by Moose spolka z ograniczona odpowiedzialnoscia and Polish National Center for Research and Development. The proposed solution allow for long-term visual observation connected with monitoring of air parameters,

thanks to power supply via a cable from the ground. An element of the system ensuring safety of flight and possibility to focus on observation instead of control of UAV is the ControlBase – ground control station (GCS) application. The GCS application is dedicated application which is the central point of MISIO system. The main features of application are: control of UAV movement with the proper safety margin, verification of flight parameters typed by user, steaming image from cameras and monitoring of air quality parameters measured by AirLAB module mounted onboard of the UAV platform.

Materials and methods

Verification of design was conducted by experimental tests in laboratory conditions and by successfully electromagnetic compatibility verification done in certified laboratory. During the tests among others the communication between the AirLAB module and GCS station computer was positively verified.

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Energy balances for nZEB modular buildings

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Keywords: *nZEB buildings, modular buildings, energy balances, thermal modelling*

Tested and computed modular building was presented (Zhelykh et al, 2021). Wooden load-bearing wall, filled with mineral wool with a cladding of external structural boards and internal fire-proofing boards – functioning as separations in case of fire has been used in the external walls and the fire resistance of the walls was increased to value REI 90. This allows of designing of the multi-story and more complex modular buildings and more complex wooden modular buildings were computed and results presented. Computations were made for a modular building (MB) with near zero energy consumption (nZEB) and connected with renewable energy sources. A specially developed AudytorOZE program dedicated to such calculations was used and the sun, wind and biomass were taken into account as the primary energy sources. The technical calculations were accompanied by economic calculations based on the current base of prices of energy carriers, building materials and renewable energy sources.

Aim of the research

Aim of the research is thermal modelling (Adamski, 2016) of the possibility of maintaining proper parameters of indoor air in the rooms (Kapalo et al, 2020) and development of nZEB modular buildings by finding such hourly periods in the heating

season, in which there is a heat deficit, despite the use of solar collectors and wind turbines. It will also be important to determine the thermal power of a biomass-fired boiler, taking into account accumulation of thermal energy.

Material and methods

Computations performed using the program AudytorOZE taking into account technical data of modular buildings and climatic data for selected towns.

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